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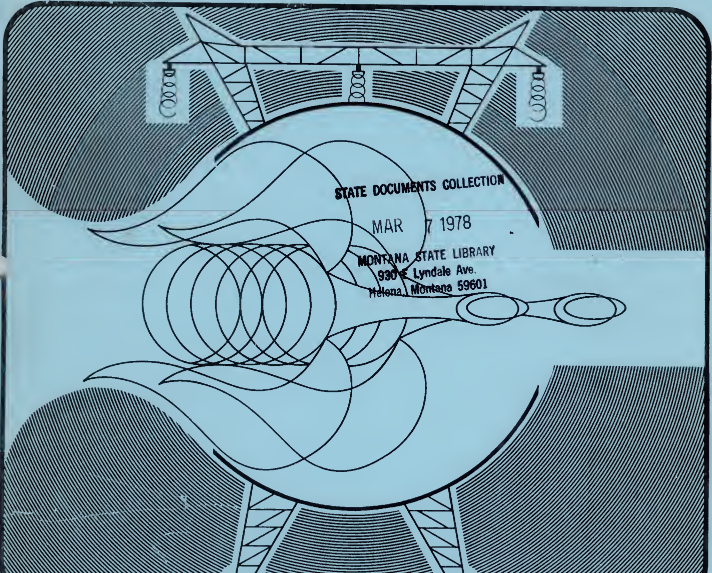
# OVERHEAD TRANSMISSION LINES

# IMPACT ON WILDLIFE



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# OVERHEAD TRANSMISSION LINES:
# IMPACT ON WILDLIFE

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RESEARCH REPORT No. 2

ENERGY PLANNING DIVISION
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
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NOVEMBER 1977

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# INTRODUCTION

The ever-increasing demand for electrical energy has resulted in a vast web of overhead transmission and distribution lines across every state of the union. As the national appetite for energy increases, many hundreds of kilometers of new lines are certain to be installed during the next few decades, with the greatest proportional increase in the larger lines. The Federal Power Commission (111) forecasts an increase in transmission facilities 230 kV and above in the United States from 104,595 circuit kilometers (65,370 circuit miles) in 1970 to 254,720 circuit kilometers (159,200 circuit miles) by 1990. The cumulative impact of such widespread habitat alteration on the wildlife resource is obviously a major concern, yet information on possible impacts to wildlife is fragmentary, geographically scattered, and often contradictory. Decisions regarding the siting of new lines result in impacts which last as long as the lines themselves and should be based upon detailed analysis of possible impacts, not upon suppositions or generalizations. One cannot readily prevent adverse impacts or maximize benefits without precise knowledge of what the potential impacts or benefits actually are.

This report provides an overview of the potential impacts of transmission lines upon wildlife, and suggestions on how impacts of new lines may be prevented or mitigated. It is based upon experience with transmission line siting and impact studies in Montana and thus places emphasis on Montana vertebrates and habitats, although findings from other regions of the United States, notably the eastern deciduous woodland, are also included. It is hoped this report will provide a long-overdue synthesis of information applicable to impact assessment and will allow a more knowledgeable approach to mitigation of the impacts of new lines to wildlife.

# OVERHEAD TRANSMISSION LINES--A GENERAL DESCRIPTION

The purpose of power lines is to transport electrical energy from source to load. Power lines differ greatly in configuration, depending on their voltage levels and specific line designs. Voltage level is generally measured in kilovolts (kV), one kilovolt equaling one thousand volts; thus, a 230 kV line is capable of being energized at 230,000 volts. In general, the size of the line--that is, the diameter of the conductors and the height of the poles or towers supporting them--increases as voltage level increases. While a 12.5 kV distribution line may be supported by 7-meter wooden poles and be barely distinguishable from a telephone or telegraph line, a 500 kV line may require 45-meter steel towers. Lines under 50 kV in capacity are usually referred to as distribution lines, while those over 50 kV are referred to as transmission lines (lines of 230 kV and above are often called extra-high voltage (EHV) lines). Most transmission lines carry alternating current (AC lines), but an increasing number carry direct current (DC lines), with one conductor having a positive charge and the other a negative charge. Except for their electromagnetic field properties, these two types of line are similar, requiring the same types of towers and clearing and construction methods, and are not treated separately in the following discussions. This report is concerned exclusively with impacts of overhead transmission lines. A much more detailed description of the types and structures of power lines will be presented in the DNR&C's forthcoming Power Line Handbook (251).

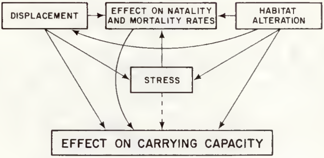
A transmission line's existence can be broken down into several stages. Briefly, these are: 1) corridor selection, or the location of a strip of land (generally several kilometers wide) in which the line will be built; 2) centerline selection, or the specific location of poles or towers, conductors, and access roads within the corridor; 3) survey and staking, which may be concurrent with centerline selection; 4) construction, during which the right-of-way may be cleared, access roads are installed, poles or towers assembled or erected, and the conductors strung; 5) operation, or the period of time during which the line is used to carry electricity and is actively inspected and maintained; and 6) postoperation, or the period after the line is abandoned or dismantled.

Obviously, the types and magnitude of potential impacts to wildlife depend largely on the size and type of transmission line; a 500 kV steel-tower line will require a much wider right-of-way and probably more vegetation removal than a 69 kV single-pole line. The different stages of the history of a power line also differ in risk for wildlife impact--construction and operation usually result in much more disturbance than corridor selection, which may involve no on-site work at all. These differences must be kept in mind when assessing the impacts of a particular line. The discussion of impacts which follows is qualitative, based on general types of impacts common to lines of all sizes; quantitative differences in degree of impact depend not only on the size of the line but many individual circumstances as well.

# TYPES OF POTENTIAL TRANSMISSION LINE-RELATED IMPACTS TO WILDLIFE

An impact to wildlife may be defined as any environmental change which results in a departure of population levels from the existing carrying capacity of the environment (that is, the optimum number of animals which the environment can support over a long period of time). Thus, an adverse (or negative) impact to a particular species is an environmental change which: 1) reduces population size below the existing carrying capacity of the environment, 2) increases population size above carrying capacity, or 3) reduces existing carrying capacity. A beneficial (positive) impact may be defined as an environmental change which 1) restores depleted or oversized populations to carrying capacity, or 2) increases carrying capacity.

It is convenient to group potential impacts to wildlife into four categories: 1) habitat alteration, 2) displacement, 3) changes in mortality or natality rates, and 4) stress. Complex relationships exist among these four somewhat arbitrary impact categories and their ultimate effect upon carrying capacity, as illustrated in Figure 1. Each of these impacts may be either positive or negative, depending upon circumstances and the nature of the particular species involved. Also, these impacts may be short-term (temporary) or long-term (permanent). Those resulting from the actual act of transmission line construction are generally short-term; those resulting from the physical presence of the poles, conductors, cleared rights-of-way, and access roads are long-term and can affect animal populations as long as the facility exists.


DISPLACEMENT
EFFECT ON NATALITY AND MORTALITY RATES
HABITAT ALTERATION
STRESS
EFFECT ON CARRYING CAPACITY

MAJOR TYPES OF IMPACTS TO WILDLIFE AND THEIR EFFECT ON CARRYING CAPACITY

FIGURE 1

## HABITAT ALTERATION

The habitat of an animal species may be defined as an area having environmental conditions which support, or which could potentially support, natural populations of that species. Species differ considerably in habitat specificity; some, like the coyote, can thrive in a variety of habitats ranging from coniferous forests to sagebrush semideserts; others, like the black swift, are restricted to a specific habitat. Also, habitat preferences of many species shift seasonally, as illustrated by migratory elk and most species of birds. The importance of suitable habitat to the well-being of animal populations is obvious. Carrying capacity is largely a function of habitat quality; if habitat is altered in such a way that it no longer fulfills the life requirements of an animal species, the ultimate number of animals which that habitat will support (carring capacity) will be reduced.

### Habitat Alteration Resulting from Vegetation Removal

Probably the most dramatic ecological impacts of transmission lines are related to the removal of vegetation from the right-of-way. In wooded areas, trees and brush which could touch the conductors are generally removed from a strip of land on either side of the line. In certain cases, all trees are removed from the right-of-way, resulting in a miniature clearcut. In others, only trees which pose an immediate problem are removed, forming a "feathered edge" configuration. In either case, taller trees or snags which could fall upon the conductors or towers are usually removed from the area.

The ecological changes resulting from logging or clearcutting of forested habitats have been extensively studied. These findings are generally applicable to transmission line rights-of-way, although several important differences should be kept in mind: 1) clearcuts are often nearly as wide as long, while right-of-way clearings are long and narrow; 2) clearcuts usually require many parallel access roads, and right-of-way clearings may require as few as one; and 3) regrowth of trees is encouraged on clearcuts but prevented or impaired under transmission lines. Some of the most important consequences of vegetation removal along transmission line rights-of-way are discussed below.

Changes in Food and Cover Availability. Where tree removal along the right-of-way opens the forest canopy, extensive changes in understory vegetation will occur, especially where dense stands of conifers are cleared. These changes may represent either a net increase or a net decrease in food or cover availability, depending upon the species of animal being considered. As Pengelly (277) summarizes these effects, "Some clearcut logging benefits some species of wildlife in some areas some of the time."

A commonly-cited impact of timber clearing--one which has caused much confusion and controversy--is the resultant increase in production of seral shrubs and forbs in the clearing, which may provide food for a variety of herbivores as well as cover for small mammals and birds. The extent of shrub regeneration depends on a number of site-specific factors, and its availability or usefulness to larger herbivores (such as deer and elk) depends not only on the availability of cover in the area but also on local habitat preferences and use patterns of the animals and the availability of food in surrounding areas.

Clearing and/or burning of certain forest types, particularly moist sites having a shrubby understory, can increase browse production (34, 57, 100, 128, 273, 274, 276, 294, 363). Clearing of drier forest types, however, is likely to produce little additional forage (87). Deer and elk are likely to benefit from increased forage production on winter ranges, but probably do not benefit appreciably from increased production on summer-fall ranges where food is already abundant (266). Another consideration is the actual availability of the forage produced. Abundant browse will not benefit large herbivores in areas which are inaccessible to them or which are avoided because of disturbances such as factories or residences. The availability of browse to large herbivores is partially dependent upon distance from cover; elk in particular are reluctant to venture into the center of large clearcuts far from tree cover, even though abundant browse exists there. Several studies (128, 294, 295, 357) have shown that in uniform stands of certain forest types, removal of trees in narrow strips (such as transmission line rights-of-way) can be more beneficial to herbivores than removal of timber in large blocks because the forage is available a short distance from cover. Other studies (89) found that the size of clearcuts has little effect on elk use.

As an example of the importance of site factors in determining effects of right-of-way clearing on large herbivores, consider the situation in the coniferous forests of western Montana. The higher-elevation coniferous forests (dominated by spruce, lodgepole pine, and subalpine fir) are used extensively by elk and mule deer only in summer and fall. At this time of year, food is abundant, the animals are dispersed, and food availability is not limiting to populations. More important are security areas and cover, which recent studies (109, 190, 219, 227, 229, 231, 242, 288, 289, 292, 329) have indicated may in fact become limiting to populations as their availability decreases. Intrusion of a cleared corridor and/or access roads into such areas will certainly decrease the availability of summer-fall security areas to the animals (see following section, "Displacement") and may thus reduce carrying capacity.

In late fall, heavy snows force animals from the higher mountainous areas, and they concentrate or "yard up" in certain restricted areas of lower snow depth, available food, and relative security from human disturbance. On these winter ranges, animals are often forced into much closer proximity to humans than in summer, although they avoid extensively man-altered land (such as heavily built-up areas). Food availability is important to these wintering elk and deer, but it is essential to realize that the type of food used differs from area to area. In western Montana, winter ranges are of two distinct types. First, in moist, heavily timbered lowland forests of Douglas fir and Ponderosa pine, such as the Burdette Creek area west of Missoula, wintering deer and elk subsist largely on browse because few grassland areas are found (51, 219, 229, 385). In these situations, forest canopy removal such as that caused by fire, logging, or right-of-way clearing can stimulate browse production and hence increase food availability without greatly affecting escape cover. Second, in the Bitterroot Valley-Sapphire Mountain area, less than 80 km (50 miles) away, winter ranges are characterized by wind-swept, grassy, south-facing slopes interspersed with fingers of Ponderosa pine and Douglas fir forest, and the animals subsist largely on grasses blown free of snow by the wind (35, 241, 242, 288, 289, 329). The interspersion of grassland with forested areas is essential, as the animals will seldom travel far from tree cover. Overstory removal in these areas will do little to increase food availability, as the understory of these drier forest types contains neither the abundant browse characteristic of Burdette Creek nor abundant bunchgrass. More important is that tree removal eliminates an essential component of these winter ranges, namely, escape cover, and can be expected to reduce the carrying capacity of the area.

Changes in Microclimate. Removal of the forest canopy results in a variety of ecological changes other than changes in vegetation, some of which may have minor effects on particular animal species (148, 150, 276). Some of the changes in microclimate which can result from forest clearing are: increased snow depth due to drifting, which can bury forage and impede travel of larger mammals; increased wind velocities, which may chill animals during storms and decrease their use of the area; increased insolation, which may increase summer ground temperatures; and even changes in dew accumulation, which at least one study (239) has indicated may affect use by ruffed grouse.

Effects of Snag Removal. Several recent studies (36, 65, 81, 167, 168, 234) have documented the importance of dead trees and snags to hole-nesting birds, especially woodpeckers. Removal of such "hazard trees" from the vicinity of power lines can significantly decrease the availability of nesting habitat for such cavity nesters.

Edge Effect. Aldo Leopold (221) has remarked that wildlife "... is a phenomenon of edges,..." occurring "... where the types of food and cover which it needs come together, i.e., where their edges meet." Edges or ecotones between broadly different habitats (e.g., forest and grassland), because they harbor species common to each habitat plus additional species which are specifically adapted to edge physiognomy, can be especially rich in wildlife species. Thus, the effects of increased "edge" created by right-of-way clearing through forested areas are of special interest.

In general, species which are adapted to closed-canopy or near-climax forest situations decrease or are eliminated as a result of forest clearing, while species preferring open-canopy situations, disturbed areas, ecotones, and seral vegetation (especially seed-eaters) will increase or colonize the cleared area (43, 122, 131, 136, 138, 146, 239, 294, 343). The net result is often an increase in species number, diversity, or abundances at the margins of the clearing (122, 138, 146, 212, 316).

Unfortunately, transmission line-related edges have received little study, and the beneficial effects of such an edge may frequently be overemphasized. A transmission line right-of-way is a unique type of forest clearing, having an extremely low ratio of width to length. The seral habitats developing on rights-of-way occur as long but narrow strips, and while differing in physiognomy from adjacent forest, often differ little in vegetative species composition from the forest understory (unless graded and reseeded). Even if the right-of-way supported, for example, well-developed grassland in sharp contrast to adjacent conifer/shrub forest, sedentary grassland animal species would be slow to colonize the right-of-way--if they would indeed colonize at all--unless an extensive grassland community to serve as a source fauna occurred nearby.

Anderson et al. (7) studied bird communities on transmission line corridors of four widths (12, 30.5, 61, and 91.5 m) in eastern deciduous forest. Typical open-country bird species were found to colonize the wider corridors, but these were primarily summer residents rather than permanent residents, and distances to grassland source areas were unspecified. All corridors studied were found to have a lower bird species diversity than undisturbed forest, even though most forest species appeared to be strongly attracted to the corridor, and the 30.5 m corridor supported a higher density of territorial males than adjacent forest. Of the various widths of corridors studied, 30.5 m appeared to show the greatest "edge effect," as narrow corridors showed little change and wider corridors produced a shift toward grassland bird communities.

Schreiber et al. (316) noted that edge habitats along power line rights-of-way supported the greatest numbers of small mammal species of all habitats studied. Other studies (23, 131), however, have shown that in some cases ecotones may support the same or lower numbers of species than do adjacent communities, and that ecotonal species are often "weed species"--that is, relatively common species having a broad range of tolerances, high dispersal ability, and high reproductive rates.

The importance of scale of habitat patches in determining edge effect has been discussed by Thomas et al. (344). Animals having large home ranges which prefer the seral vegetation found in a cleared right-of-way, but whose home ranges do not "fit" in the narrow right-of-way, are not as likely to benefit as much as species having smaller home ranges. Also, right-of-way-created edge is usually abrupt and uniform, and involves only two or three differing habitats. There is much evidence that complexity and patchiness of vegetation is more important in determining species number than edge per se (3, 302, 377), and that such abrupt edges would result in little increase in species number compared to a complex mosaic of many interdigitating types broken up into islands and peninsulas of widely varying size and shape. As Kelker (184) puts it, "abundance of resident species requiring two or more cover types appears to depend on the degree of interspersion of numerous blocks of such types." Preliminary investigation of transmission line rights-of-way through the coniferous forests of western Montana has indicated little, if any, increase in number or abundance of birds compared to adjacent forest. Clearly, much more work is needed to assess wildlife use of transmission line-related edges.

Chemical Control. Use of herbicides to control regrowth of vegetation in cleared rights-of-way can have a far-reaching impact to communities of animals using the rights-of-way. Such ecological changes have been discussed by several authors (57, 58, 60, 69, 74, 129, 135, 174, 183, 199, 211, 220, 245, 246, 260).

### Habitat Alteration by Access Road Construction

Where permanent access roads are maintained along rights-of-way, a small amount of habitat equivalent to the area of the road is permanently altered. This does not constitute a significant impact unless a high percentage of a habitat which is limiting to a species is destroyed, as in the case of willow-bottom moose habitat.

### Use of Poles or Towers by Nesting Birds

Transmission line poles and/or towers are often used as hunting perches or nest support structures by osprey, golden eagles, ravens, and red-tailed hawks in the western United States (108, 131, 142, 328). Osprey in Montana are known to nest on 115 and 230 kV wooden poles where the lines pass near the Blackfoot and Flathead rivers in areas lacking suitable natural nest sites (figure 2). Raptor nests on metal towers can cause reliability problems; for example, flashovers caused by bird excretions bridging conductors may result in outages. Some utilities have resorted to moving problem nests to sites on towers where flashovers will be unlikely, with birds continuing to use these relocated nests year after year. The Bonneville Power Administration recently began installing wood-and-fiberglass nest platforms on poles where very large raptor nests were threatening service (214). The overall effect of increased nest-site avaialability on raptor populations has not been determined, although it may very well increase carrying capacity in areas where nest site availability is a limiting factor.

### Fragmentization of Habitats

The effects of fragmentization or isolation of large blocks of uniform habitat upon animal species number and diversity have recently been examined in light of MacArthur and Wilson's theory of island biogeography (232). Most researchers (94, 95, 116, 120, 235, 335) agree that large contiguous blocks of habitat must be preserved in order to maintain species diversity, although some workers have argued to the contrary (323). Larger blocks of habitat support more species of birds and mammals than do smaller stands, and division of such "habitat continents" into smaller "habitat islands" reduces the number of species using that habitat. The effectiveness of a transmission line right-of-way or access road as a barrier separating adjacent stands of habitat is probably minimal, except in the case of small and sedentary mammals which are reluctant to cross rights-of-way or access roads (271). Schreiber and Graves (315) studied movements of two species of small mammals and found the animals to freely cross cleared rights-of-way as wide as 103.6 m. Forest-interior birds (those requiring large uniform stands of closed-canopy forest), however, may be eliminated from areas where larger forest stands have been broken up by roads and clearings (371, 372).

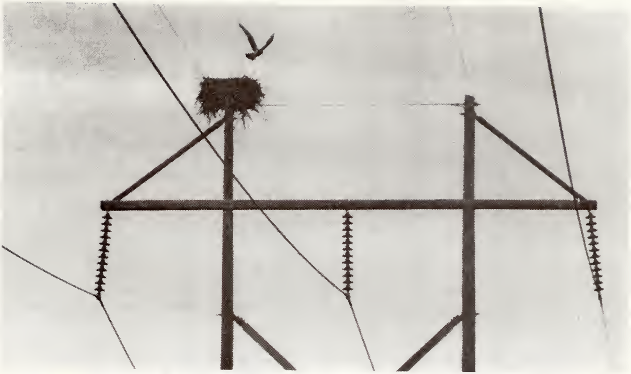


Figure 2. Birds of prey occasionally use transmission line support structures as nesting sites. This photograph shows an osprey nest built on a 230 kV double-pole tower structure near Ovando, Montana. The effect of induced electromagnetic current surrounding the conductors on the developing eggs and young birds is unknown; this nest has successfully produced young for several years.

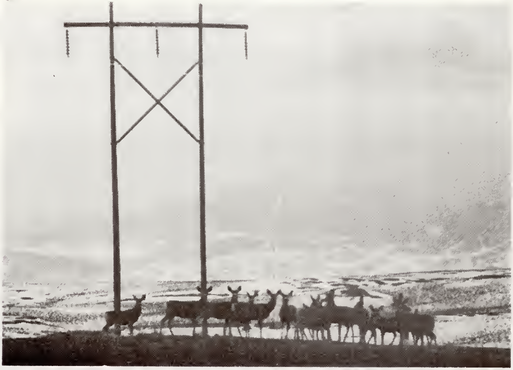


Figure 3. Mule deer on a Montana winter range near Clyde Park do not avoid energized 161 kV transmission lines in spite of a noticeable hum. Apparently, the deer become habituated to the noise much as they become habituated to natural sounds such as those produced by streams or wind.

Of particular interest is the fragmentization of "unaltered" habitats (referred to in common usage with such terms as roadless, primitive, natural, wilderness-like, and pristine) by rights-of-way and attendant access roads. These habitats are not only essential to such "wilderness-loving" species as grizzly bear, mountain lion, lynx, marten, and fisher, but also provide critical security areas for big game species, notably elk and mule deer. A power line which traverses a large block of unaltered habitat has a much greater impact than merely fragmenting it into two smaller units; it can potentially destroy the "unaltered" nature of the habitat over an area much greater than that of the roads or rights-of-way themselves, including a fringe of land of variable extent on eigher side. This may be due to increased human use of the roads (as discussed in the following section), or it may be due to changes in land use in the newly-opened area, the power line serving as a wedge to open the area to residential, recreational, logging, or agricultural development, with subsequent negative consequences. Thus, if a 10,000-hectare wilderness-like area is bisected by a 100-hectare power line right-of-way, the actual amount of wilderness habitat which remains may be considerably less than 9,900 hectares.

Habitat fragmentization by power lines, although it may not result in immediate and obvious changes in wildlife communities, is by no means unimportant. This piecemeal erosion of habitat is all too often ignored, although it places irreversible constraints on the future availability of large uniform habitat stands and can become significant as further fragmentization due to other causes continues.

## DISPLACEMENT

Displacement, or population redistribution resulting from disturbance or other environmental change, is a special case of habitat alteration which causes animals to avoid an otherwise suitable area.

### Short-term Displacement

Temporary disturbances associated with line construction (such as surveying, forest clearing, tower erection, or wire stringing) cause a short-term displacement of most birds and mammals--that is, the animals respond by moving away from the disturbance, then return after a period of time. The actual distances moved and the amount of time before return, two factors which determine the severity of impact, are dependent upon the habits of the species involved as well as the type, distance, and severity of disturbance. Movements may vary from several meters in the case of small rodents and songbirds to many kilometers in the case of larger birds. The avoidance of active timber removal and road construction by large ungulates, especially elk and moose, is well documented (5, 35, 289, 292, 330, 360, 361). This displacement may be evident, in the case of elk, up to 6.4 km from the site of disurbance (229, 292). Breeding birds, notably raptors and colonial water birds, may abandon eyries or rookeries if displaced early in the breeding season (22, 328, 367), and sage and sharptail grouse may abandon historical display grounds. Even if breeding sites are not abandoned permanently, flushing of incubating or brooding adults from nests may result in loss of young due to exposure or premature fledging. With these exceptions, the overall impact of construction-related displacement upon carrying capacity is generally insignificant, as displaced animals will eventually resume normal activity, insofar as habitat alteration allows, once construction ceases.

### Long-term Displacement

A more serious type of impact is long-term displacement, or permanent avoidance of a disturbed area. Such avoidance is equivalent to a permanent reduction in carrying capacity in the sense that previously used habitat is made unavailable to the animals. Two important sources of long-term displacement which may result from transmission lines are (1) the avoidance of noise, poles, and conductors, and (2) the avoidance of roads and vehicular traffic.

Avoidance of Noise, Poles, and Conductors. Many misconceptions surround the question of avoidance of energized transmission lines by large ungulates. Klein (192) reported that reindeer in Norway are reluctant to travel beneath power lines, especially during the first year or two following construction; this appeared to result both from the hum emitted by the lines and from the structures being foreign objects in otherwise familiar surroundings. This report and others have lead to the misconception that ungulates avoid power lines in all situations.

Noise produced by corona discharge from energized conductors may approach 70 dB on some 500 kV and 765 kV lines (215, 309), although Griffith (131) reported a maximum of 38 dB produced by a ±400 kV DC line. The effect this noise may have on animal distribution is largely speculative. Goodwin (128) suggests that large ungulates readily habituate to such background noise, much as they habituate to natural sounds such as those produced by streams or the wind. Indeed, there is no evidence that North American ungulates avoid transmission lines because of the visual configurations of the poles and wires, induced electromagnetic fields, or noise created by corona discharge, and these animals are often seen feeding or bedding in proximity to energized lines (figure 3; see also 128).

Noise created by corona discharge may have some effect on smaller animals, however, Potash (285) found that the frequency of separation calling in Japanese quail increased significantly as ambient noise levels increased. There has been some speculation that noise in transmission line rights-of-way may serve to compress territories of those breeding bird species which advertise their territories by singing, but this has yet to be demonstrated.

Information on avoidance of transmission lines by waterfowl is contradictory. There is some evidence that birds may be able to sense the presence of electric fields surrounding energized lines, but it is not known if the birds react by avoiding the lines while in flight (215). Indeed, large concentrations of waterfowl and other birds are often seen in the vicinity of energized lines, and this situation often results in losses of birds through collisions with conductors (see section on "Wire Strikes" below). However, there are reports to the effect that waterfowl avoid transmission lines while in flight by distances of up to 0.8 kilometers (72, 164). It is suggested that these birds are reacting to light reflected by the lines, the humming of the lines, and the visual configuration of the lines, especially when the lines are swaying in the wind. Other reports provide evidence that power lines can cause waterfowl to fly too high to be in range for hunting. In a 1970 Nebraska case, a wetland owner received a settlement of approximately $90,000 for damage to his property and hunting locale resulting from a transmission line (52), and Drennen (72) cites a case in which a commercial duck hunting club had to be moved as a result of the nearby construction of transmission lines. Bellrose (72) has presented testimony that immediately above a transmission line there is an almost total absence of ducks, and that the effect reaches out as far as 0.4 km on each side of the line. Gulls appear to be particularly reluctant to fly under operating transmission lines (133). Fog (115), however, reports that ducks and geese in Denmark fly under and between energized 151 kV conductors without apparent fear.

Certain species having specialized behavior patterns with which conductors interfere with may exhibit avoidance of rights-of-way. Birds such as the horned lark whose aerial courtship displays were inhibited by the presence of conductors were found to be less abundant in right-of-way habitats than control habitats (131, 132).

Avoidance of Access Roads and Associated Human Activity. Roads created for transmission line construction access are often maintained to allow access to the lines for maintenance and inspection. Even if such roads are closed or are not maintained, they are frequently used by hunters, motorcyclists, snowmobilers, or other recreationists. Thus, the potential exists for long-term displacement of those species which avoid traffic or other human activity.

Elk appear to be among the species most vulnerable to displacement by vehicular traffic. Many studies have documented the avoidance of roads by elk (4, 5, 230, 231, 292, 301, 336), but others (361) suggest that traffic has little effect on elk activity beyond 0.3 km. The sensitivity of elk to disturbance is largely dependent upon season and condition of the animal; also, many logging roads which are avoided during daylight hours, when traffic is present, are freely crossed at night. Other big game mammals, including moose, mountain goats, and deer, are also known to avoid roads and associated human activity.

Dispersed recreation and off-road vehicular travel, especially snowmobile use of the cleared right-of-way, can also result in displacement of large ungulates (25, 128, 154, 359, 360, 361, 362). Deer apparently can become readily habituated to light, constant snowmobile activity; however, deer react violently to snowmobile invasions into areas where snowmobiles seldom travel. Elk appear less tolerant than deer to snowmobiles and will move relatively great distances to escape the disturbance.

Goodwin (128) reports increased hunter use of the right-of-way and access roads of a 500 kV line in Idaho to be the major negative impact on big game animals observed during his study. Hunters tended to concentrate along roads, trails, and clearings, and seldom hunted more than 1.6 kilometers from a road or clearing. This increased hunting pressure was found to displace elk to areas 0.8 kilometers or more away from the right-of-way or access roads.

Griffith (131) also reported heavy use of transmission line access roads in Oregon during deer season.

Most mammals and birds can habituate to many kinds of unfamiliar environmental stimuli which are initially disturbing, provided the stimuli are constant or repeated regularly. For example, an attempt was made in northern Idaho to drive nuisance elk from cultivated fields with firecrackers and exploding rockets, but the elk became conditioned to these repeated disturbances after four to five days and no longer responded to them by fleeing (128). Similarly, big game animals can become conditioned to constant vehicular traffic, even if traffic is heavy and noise levels are high, and are often seen feeding near interstate or other major highways. However, disruption of this rhythmical traffic pattern represents a new, unfamiliar stimulus; the animals will usually cease feeding and move if a vehicle suddenly stops nearby and its occupants appear. Where traffic is infrequent or highly irregular, as on many dirt or primitive mountain roads, there is little opportunity for animals to become conditioned to traffic, and their avoidance of vehicles is greatest. The same probably occurs along transmission line access roads in otherwise roadless areas. This long-term displacement can effectively reduce the amount of available habitat over an area much greater than that of the road itself, an area which, in the case of elk, may include a strip of land extending 0.5 km or more on either side of the road--a net reduction in carrying capacity.

The magnitude of these impacts may vary tremendously from area to area and depends upon a complex interaction of many site-specific variables, including the age, type, and location of existing roads, distances to population and developed recreation centers, traffic density, hunting pressure, species of animals present, and whether the road is located in an abundant vegetation type or in a scarce and limiting one.

## CHANGES IN MORTALITY RATES

Mortality, of course, is a natural and necessary ecological phenomenon. Without it, every species of animal would have the potential to overwhelm the earth. Increases in natural mortality rates are normally compensated for by increases in birth rates, the result being that most populations of animals are regulated at or near carrying capacity. Increased mortality rates, then, are a serious impact only when they exceed the potential of the population to recover. If continued for long periods of time, this can result in local or regional extinction. Populations most likely to be adversely affected by increased mortality are those of: 1) species with a low reproductive potential, such as the black bear and trumpeter swan, 2) species which are already very rare or in danger of extinction, such as the black-footed ferret, and 3) species living in small isolated colonies which can be easily eliminated, such as the prairie dog and great blue heron. Small mammals and other species with a high reproductive potential are adapted to high natural mortality rates; often, very high mortality can be compensated for in a few months or years. Transmission lines or associated roads may contribute to increased mortality rates of some species in four important ways, discussed below.

## Wire Strikes

Collisions with utility wires, or wire strikes, have been known to result in the mortality of waterfowl (38, 55, 83, 143, 198, 333, 375) and a wide variety of other birds, including ring-necked pheasant (198), sage grouse (53, 255), Allen's hummingbird (147), and sandhill crane (356). Raptors, due to their superior eyesight, are seldom the victims of wire strikes. Transmission line poles and towers do not cause the dramatic bird kills reported for the much higher radio towers and ceilometers (see Index to References under "Collisions with Towers," page 24).

Waterfowl generally migrate at sufficient altitudes that collisions with power lines are unlikely, except near feeding, nesting, or resting areas, or overmountain passes or high ridges, where birds fly near the ground. As mentioned earlier, waterfowl may avoid transmission lines in some instances. Wire strikes by waterfowl are most frequent during spring and fall migrations, when the birds pass through relatively unfamiliar terrain, and during windstorms, snowstorms, periods of heavy fog, or other meteorological phenomena which reduce visibility (287, 375, 376). Fifteen sandhill cranes found by Walkinshaw (356), however, apparently collided with a power line during a period of clear and calm weather, and Lee (215) and Willard et al. (374) report several wire strikes observed during clear weather.

Krapu (198) and Boyd (55) report that teal and diving ducks are especially susceptible to collisions with overhead wires due to the high speed and low altitude of their flights. Stout (333) reported that puddle ducks appear more vulnerable to wire strikes than other waterfowl species. Swans, geese, pelicans, and cranes are also particularly vulnerable due to their great size and limited maneuverability (38, 215, 374). The young of most waterfowl speceies are generally more susceptible than older, experienced individuals (198).

Mortality caused by wire strikes is likely to represent a relatively small percentage of the total nonhunting mortality of waterfowl, (12, 334) although losses may be locally heavy where lines cross high-use areas.

## Electrocutions

Electrocution of birds perching on power lines, including raptors, herons, crows, ravens, and wild turkeys, has been well documented (6, 49, 50, 142, 257, 296, 303). These electrocutions result from simultaneous contact of two conductors or a conductor and ground wire by birds perched on poles or wires. However, nearly all such electrocutions are associated with power distribution lines; the distances between wires of high-voltage transmission lines are greater than the wing spans of most birds, making electrocutions by such lines unlikely (85, 142).

## Shooting

The tendency of large raptors to perch on utility poles in open areas makes them vulnerable to illegal shooting, especially in areas where the transmission line closely parallel roads or where the public has access to maintenance roads (49, 50, 142). Ellis et al. (108) describe deliberate target shooting and even after-dark spotlight shooting of at least 38 raptors, especially golden eagles, over a 1.5-year period along 19.2 km of utility line paralleled by a gravel road.

## Changes in Hunting Pressure

Transmission line access roads have the potential to alter the distribution of hunters, and to change the rate of harvest mortality of many game species. In areas already heavily roaded, increased access by hunters can further reduce the availability of security areas to big game, and result in harvest quotas being reached faster. This may result in more restrictive hunting regulations and reduce the quality and quantity of hunting opportunities available in a given area.

Increased hunter access resulting from road construction has changed hunting regulations in several parts of Montana. Logging and the construction of roads into previously unroaded areas of the Gravelly, Little Belt, and Bitterroot mountains of Montana have resulted in more restrictive elk hunting regulations, especially a reduction in the number of days of open either-sex hunting. Generally, the change in regulations occurs the first year or two after road construction (4). However, in certain areas a lack of hunter harvest can be detrimental to elk populations in areas where natural predators are lacking, and can result in degenerate population age structure (128).

The relationships among access, hunting pressure, and game populations have been studied by experimentally closing certain road segments in the Ruby and Little Belt mountains. Lonner (227) found that the Ruby Mountains road closure apparently increased hunter success and incidence of elk observation, increased elk use of the restricted area, and resulted in a more uniform season-long hunting pressure and elk harvest. Basile (33), however, found the Little Belt Mountains road closure to have no apparent effect on hunting pressure or elk distribution, although the number of elk seen by hunters increased by nearly 50 percent.

## STRESS

This category includes impacts which are sublethal, difficult to identify, and which may not result in immediately observable population changes. As shown in Figure 1, stress may increase as a result of displacement of habitat alteration, and may indirectly affect mortality and natality rates. For example, repeated displacement of wintering elk into areas of deep snow is not likely to kill the animals directly, but it may cause abortions or predispose the animals to mortality through other causes, such as predation, disease, or starvation. Even slight increases in stress and the expenditure of stored energy, such as would result from the displacement and harassment described earlier, are important during winter, when most animals are already under severe stress. Two additional sources of possible power line-related stresses are discussed below.

## Oxidants

A number of gaseous oxidants toxic to animals can be produced by corona discharge in air from electrical apparatus; these include ozone and oxides of nitrogen (170, 299). Corona discharge resulting from high-voltage transmission lines has the potential to produce these oxidants; however, Fern and Brabets (112), Frydman et al. (119), and Scherer et al. (308) found no measurable amounts of these oxidants attributable to corona discharge in the air surrounding 765 kV conductors in a variety of weather conditions. There is no conclusive evidence that high-voltage transmission line conductors will produce oxidants in quantities harmful to animals living or passing beneath the lines.

## Electromagnetic Effects

Living organisms may incur physiological changes as a result of electromagnetic fields surrounding extra high voltage transmission lines. The alternating electric field in the air surrounding these lines induces small "charging currents" in the tissues of animals near the lines. These body currents have been found to approach 0.4 milliamperes in men working near 345 kV lines (196, 384). Nerve and brain tissues, whose proper functioning depends upon the maintenance of a small difference in electric charge between the inside and outside of individual cells, were found to be especially vulnerable to long-term exposure to induced alternating currents (298). Studies in the Soviet Union have suggested that men working at 500 kV substations and subjected to intense electromagnetic fields for long periods appear to suffer headaches, abnormal fatigue and sleepiness, and reduced sexual potency as a result of the fields' "...shattering the dynamic state of the central nervous system, heart and blood-vessel system, and ...blood structure" (16, 195). It was also found that male mice exposed to strong electric fields for 6½ hours a day over a 10½ month interval produced smaller litters than other males when bred with normal females; they also appeared to sleep more than unexposed mice (193). Monkeys exposed to electric fields similar to those in the vicinity of operating power lines showed a significant alteration in interresponse time, reflecting possible neurological changes (384). The stresses incurred by such animals would possibly predispose them to increased mortality.

Bingham and O'Neil (unpublished memorandum to C. R. Foleen, BPA, Feb. 13, 1974), however, question the validity of the above studies, and report that follow-ups to the USSR studies have not revealed any adverse effects resulting from exposure to EHV lines. The magnitude and nature of electromagnetic effects on birds raised in nests near conductors on transmission line towers or poles are not known. Birds raised in close proximity to the conductors would undergo embryonic development and growth while continuously subjected to changing body currents, but there is no evidence documenting resultant damage to the birds. Broods of several species have been successfully raised and fledged on 500 kV towers near energized conductors with no apparent ill effects (Figure 2). It is doubtful that electromagnetism has any measurable effect on populations of wild animals living near power lines.

# MITIGATION OF IMPACT

The previous discussion deals with potential or possible impacts of transmission lines; the severity of actual impacts which result from a particular project depends on many factors, such as the location and size of the line and the timing and method of construction, and can vary from slight to severe depending upon the effort toward mitigation of impact. Potential impacts to wildlife can be reduced--or in many cases prevented--by spatial, temporal, or operational mitigation. Spatial mitigation is simply the avoidance of areas with a high potential for adverse impact; for example, nest sites or winter ranges. Temporal mitigation involves restricting disturbances to seasons when impact risk is least. For example, construction activities in the vicinity of an active osprey nest are unlikely to affect the osprey if confined to the fall and winter months. Figure 4, which shows periods of greatest sensitivity at selected seasonal use sites in southwestern Montana, may be of use in planning schedules to minimize wildlife impacts. Operational mitigation involves the employment of methods or techniques which could reduce impact risk, for example, use of horses rather than heavy machinery in timber removal.

It is essential to consider mitigation of impact at three key stages in the transmission line siting process: corridor selection, centerline selection, and construction itself.

## MITIGATION AT THE CORRIDOR SELECTION STAGE

Transmission line siting is often approached initially by the identification of a corridor, often two km or more in width, which is broadly suitable for location of a transmission line. Corridor selection can mitigate impacts to wildlife only in the broad sense that, if the areas of greatest impact risk (especially roadless areas) are avoided, the chances of adverse impact to wildlife are reduced. The identification of such areas of high wildlife impact risk is an important but often difficult part of the siting process; one possible approach to the problem which has been applied to transmission line siting in Montana is described by Thompson (345, 346).

## MITIGATION AT THE CENTERLINE SELECTION STAGE

Centerline selection allows a more precise level of impact mitigation, and may be more important than corridor selection in its effect on wildlife habitat. Many possible adverse impacts to wildlife can be mitigated by choosing a centerline which:

1. Avoids specific sites of high impact risk, such as nest sites, colonies, leks, and high-use waterfowl areas

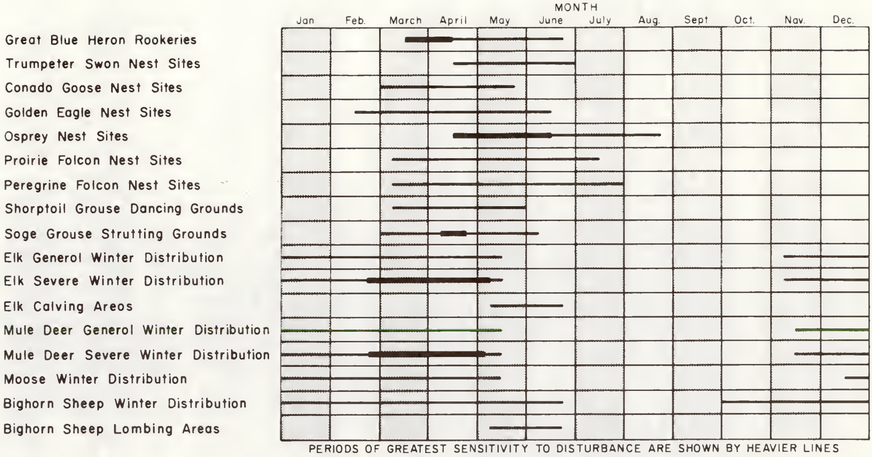


Figure 4. Periods of greatest sensitivity to disturbance at selected seasonal use sites in Montana.

2. Avoids other areas which are locally valuable to species of concern, such as willow bottoms, security areas, winter concentration areas, or roadless "wilderness-like" habitats

3. Makes use of existing access roads rather than requiring new ones

4. Crosses or closely parallels areas which are already avoided by major species (for example, large clearcuts or industrial areas) or where the animals are already somewhat habituated to human activity (such as in the vicinity of major roads)

5. Makes use of existing forest clearings or nonforested areas so that extensive right-of-way clearing is not necessary

6. Avoids ridge lines in areas of elk summer range

7. Preserves security areas separated from the construction site by a line-of-sight barrier in areas of elk summer range

## MITIGATION AT THE CONSTRUCTION STAGE

Proper methods and timing of transmission line construction may be more important than the geographical location of the line itself. Impacts of transmission line construction through a given area can be greatly mitigated in many cases, even if the corridor or centerline crosses areas of high impact risk.

Many of the possible construction-related impacts to wildlife can be mitigated by:

1. Prohibiting construction through seasonal use areas or in the vicinity of breeding sites during periods when the sites are occupied (see Figure 4)

2. Prohibiting off-road vehicular travel by construction crews

3. When seasonal use areas or breeding sites cannot be avoided, planning construction so that it can be accomplished as quickly as possible, perhaps by scheduling double work shifts in these areas

4. Employing roadless construction methods, such as use of helicopters, where the centerline must cross forested roadless areas

5. Halting construction and movement of machinery when the ground is wet with rain or melting snow

6. Limiting right-of-way clearing to the minimum necessary for line stringing and line clearance, and by "feather-cutting" rather than block-clearing of the right-of-way

7. Properly disposing of slash so as not to inhibit movements of large mammals

8. Closing and posting new access roads
9. Designing structures to reduce the probability of wire strikes; for example, by removal of static wires or use of self-supporting rather than guyed towers

Experience has shown that many of these mitigating measures may be impractical or impossible to enforce. For example, closing and posting access roads does not guarantee that they will not be used by determined hunters.

## SUMMARY

While transmission line-related impacts are not likely to cause extinctions or large-scale disruption of animal communities, they pose the very real risk of further degrading an already-declining amount of productive habitat. This may be brought about by direct habitat alteration (especially tree removal along the right-of-way), but it may also result from displacement of animals due to traffic or development along the right-of-way. Other important impacts may result from mortality of animals due to illegal shooting or wire strikes, or increased stress predisposing animals to starvation or diseases.

Experience has shown that the greatest risk of significant impacts of transmission lines on wildlife generally involves: 1) the long-term fragmentization of roadless "wilderness-like" habitat (including security areas for large mammals) by cleared rights-of-way or by access roads, since this generally results in increased human use of the areas; 2) disturbance of breeding sites of birds (especially raptors and colonial species) by construction activities or by human use of access roads or cleared rights-of-way; and 3) increased mortality rates of birds (especially waterfowl) due to collisions with conductors or other structures. Also important are the effects of increased human access on recreational use of wildlife, especially hunting; such access may result in more restrictive local hunting regulations.

Many of the potential adverse impacts to wildlife can be prevented or mitigated by judicious line placement and timing and methods of construction. Perhaps the most simple and effective way of mitigating adverse wildlife impacts is to site new lines in areas where existing disturbances--cities, roads, subdivisions, mining, existing utility corridors--already limit wildlife use and where the addition of a transmission line will cause little further impact.

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# SUBJECT INDEX TO REFERENCES

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# BIBLIOGRAPHY

1. Abbott, R. E. 1973. Transmission line rights-of-way and the environment. Arborist's News 39:35-36.

2. Ad Hoc Subcommittee on Power Transmission Lines. 1963. A report on the impacts of power transmission lines in forested areas of the Columbia Basin. Columbia Basin Inter-agency Committee. 10 pp.

3. Adams, D. L., and G. W. Barrett. 1976. Stress effects on bird-species diversity within mature forest ecosystems. Amer. Midland Nat. 96:179-194.

4. Allen, E. O. 1971. Montana Department of Fish and Game, Bozeman. Written communication to C. Sundstrom and E. Norberg (unpublished).

5. _______, and T. N. Lonner. 1974. Effects of logging on elk populations. Montana Fish and Game Progress Report, Project No. W-120-R-5, Job Nos, BG-3.04, 3.06, 3.07, 3.08, 3.09, 3.11 and 3.12.

6. Anderson, A. H. 1933. Electrocution of purple martins. Condor 35:204.

7. Anderson, S. H., K. Mann, and H. H. Shugart, Jr. 1977. The effect of transmission line corridors on bird populations. Amer. Midland Nat. 97:216-221.

8. Anderson, S. H., and H. H. Shugart. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55:828-837.

9. Anderson, W. L. 1975. Waterfowl collisions with power lines at a coal-fired power plant. Ill. Nat. Hist. Survey, Urbana.

10. _______, S. S. Hurley, and J. W. Seets. 1975. Waterfowl studies at Lake Sangchrist. Ill. Nat. Hist. Survey, Urbana.

11. Anderson, W. W. 1975. Pole changes keep eagles flying. Transmission and Distribution 27:28-31.

12. Arend, P. H. 1970. The ecological impact of transmission lines on the wildlife of San Francisco Bay. Prepared for Pacific Gas and Electric Company by Wildlife Associates.

13. Arner, D. H. 1951. Experimental plantings on power line right-of-way and woodland roads. Trans. N. Amer. Wildl. Conf. 16:331-338.

14. _______. 1966. Utility line right-of-way management. Trans. N. Am. Wildl. Conf. 31:259-268.

15. ________, L. E. Cliburn, D. R. Thomas, and J. D. Manner. 1976. The use of fire, fertilizer, and seed for right-of-way maintenance in the southeastern United States. Pages 156-165 in R. Tillman (ed), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

16. Asanova, T. P., and A. I. Rakov. 1966. The state of health of persons working in electric field of outdoor 400 kilovolt and 500 kilovolt switchyards. Hygiene of Labor and Professional Diseases, 5.

17. Auerbach, S. I., D. J. Nelson, and E. G. Struxness. 1973. Environmental sciences division annual progress report for period ending September 30, 1972. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

18. Avery, M. L., and T. Clement. 1972. Bird Mortality at four towers in eastern North Dakota - Fall 1972. Prairie Naturalist 4:87-95.

19. Avery, M. L., P. F. Springer, and J. F. Cassel. 1973. Progress report on bird losses at the Omega tower. Proc. N. Dakota Acad. Sci. 27:2.

20. ________. 1976. The effects of a tall tower on nocturnal bird migration -- a portable ceilometer study. Auk 93:281-291.

21. Bachman, C. H. and M. Reichmanis. 1973. Some effects of high electrical fields on barley growth. Int. J. Biometeor. 17(3): 253-262.

22. Baglien, J. W. 1975. Biology and habitat requirements of the nesting golden eagle in southwestern Montana. M. S. thesis, Montana State University, Bozeman.

23. Balda, R. P. 1975. Vegetation structure and breeding bird diversity. Pages 59-80 in D. R. Smith (ed.), Proceedings of the symposium on management of forest and range habitats for nongame birds. USDA Forest Service, General Technical Report WO-1.

24. ________, and C. D. Johnson. 1976. Secondary succession along major transmission line rights-of-way: a progress report. Northern Arizona University. 209 pp.

25. Baldwin, M. F., and D. H. Stoddard. 1973. The off-road vehicle and environmental quality. 2nd Edition. The Conservation Foundation. 61 pp.

26. Banko, W. E. 1960. The trumpeter swan - its history, habitats and population in the United States. North American Fauna, No. 63. April, 1960.

27. Bankoske, J. W., H. B. Graves, and G. W. McKee. 1976. The effects of high voltage electric fields on the growth and development of plants and animals. Pages 111-124 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

28. Bankoske, J. W., and G. McKee. 1975. Ecological influence of electric fields: six month interim progress report. Westinghouse Electric Corporation, East Pittsburgh, PA. 20 pp.

29. Barber, H. L. 1961. Wildlife habitat management on utility rights-of-way may provide much needed areas of food and cover in this state. Kentucky Happy Hunting Ground 17:30-31.

30. Barick, F. B. 1950. The edge effect of the lesser vegetation of certain Adirondack forest types with particular reference to deer and grouse. Roosevelt Wildl. Bull. 9:146.

31. Barnes, H. C., A. J. McElroy, and J. H. Charkow. 1967. Rational analysis of electric fields in live line working. IEEE Transactions on Power Apparatus and Systems. PAS-86(4):482-492.

32. Barnothy, M. F. (ed.). 1964. Biological effects of magnetic fields. Plenum Press, New York. 2 vols.

33. Basile, J. V. 1977. Judith road closure study. Montana Department of Fish and Game, Final Report, Job No. III-A-2. In press.

34. ________, and C. E. Jensen. 1971. Grazing potential on lodgepole pine clearcuts in Montana. USDA Forest Service Research Paper INT-98:1-11.

35. Beall, R. C. 1974. Winter habitat selection and use by a western Montana elk herd. Ph.D. Thesis, University of Montana, Missoula. 309 pp.

36. Beebe, S. B. 1974. Relationships between insectivorous hole-nesting birds and forest management. Yale University, School of Forestry.

37. Beeman, L., and R. K. Schreiber. 1976. A partial bibliography - environmental concerns in rights-of-way management. Pages 321-335 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

38. Beer, J. V., and M. A. Ogilvie. 1972. Mortality. Pages 125-142 in Peter Scott and the Wildfowl Trust, The Swans. Houghton Mifflin Co., Boston.

39. Beischer, D. E., J. D. Grissett, and R. E. Mitchell. 1973. Exposure of man to magnetic fields alternating at extremely low frequency. Naval Aerospace Medical Research Laboratory. Pensacola, Florida. 31 pp.

40. Bellis, E. D., and H. B. Graves. 1971. Deer mortality on a Pennsylvania interstate highway. J. Wildl. Manage. 35:232-237.

41. Bellrose, F. C. 1971a. The distribution of nocturnal migrants in the air space. Auk 88:397-424.

42. ________. 1971b. Bird migration in relation to the U.S. Navy's Omega Tower project at La Moure, North Dakota. Ill. Nat. Hist. Survey, Urbana, Ill.

43. Bendell, J. F., and P. W. Elliott. 1966. Habitat selection in blue grouse. Condor 68:431-446.

44. Berkshire County Regional Planning Commission. 1974. Evaluation of power facilities: a reviewer's handbook. Pittsfield, Mass. 378 pp.

45. Berntsen, C. M., R. B. Litten, Jr., L. J. Lyon, P. E. Packer, P. M. Rees, and J. E. Schmautz. 1971. Forest management in Wyoming - timber harvest and the environment on the Teton, Bridger, Shoshone, and Bighorn National Forests. USDA Forest Service. 81 pp.

46. Biological Studies Task Team. 1977. Electrical and biological effects of Transmission lines: a review. Bonneville Power Administration, Portland, Oregon. 64 pp.

47. Black, H. C., and E. H. Hooven. 1972. Response of small-mammal communities to habitat changes in western Oregon. In H. C. Black (ed.), Wildlife and Forest Management in the Pacific Northwest. Forest Research Laboratory, Oregon State University, Corvallis.

48. Blockpoel, H. 1976. Bird hazards to aircraft. Clark Irwin and Co., Ltd., Toronto, Canada.

49. Boeker, E. L. 1972. Powerlines and bird electrocutions. U.S. Bureau of Sport Fisheries and Wildlife, Forest Hydrology Lab, Arizona St. Univ., Tempe.

50. ________, and P. R. Nickerson. 1975. Raptor electrocutions. Wildl. Soc. Bull. 3:79-81.

51. Bohne, J. R. 1974. Food habits, seasonal distribution, and habitat utilization of elk in the south fork of Fish Creek, Lolo National Forest, Montana. M. S. Thesis, University of Montana, Missoula.

52. Bonde, L. J. 1970. USDI Fish and Wildlife Service, Lincoln, Nebraska. Letter to R. A. Hunt, October 5.

53. Borell, A. E. 1939. Telephone wires fatal to sage grouse. Condor 41:89.

54. Bormann, F. H., G. E. Likens, D. W. Fisher, and R. S. Pierce. 1968. Nutrient loss accelerated by clearing of a forest ecosystem. Science 159:882-884.

55. Boyd, H. 1961. Reported casualties to ringed ducks in the spring and summer. Wildfowl Trust 12:144-146.

56. Bracken, T. D. 1975. Field measurements and calculations of electrostatic effects of overhead transmission lines. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-95, p. 494.

57. Bramble, W. C., and W. R. Byrnes. 1972. A long-term ecological study of game food and cover on a sprayed utility right-of-way. Purdue Univ. Agri. Expt. Station Bull. No. 885. 20 pp.

58. _______. 1974. Impact of herbicides upon game food and cover on a utility right-of-way. Purdue Univ. Agri. Expt. Station Bull. No 916. 16 pp.

59. _______. 1976. Development of a stable, low plant cover on a utility right-of-way. Pages 168-176 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

60. _______, and R. J. Hutnik. 1958. Effects of chemical brush control upon game food and cover. Penn. Agri. Expt. Station Prog. Rept. No. 188.

61. Bremond, J. C. 1973. Acoustic behavoir of birds. In Acoustic Behavoir of Animals. Elsevier Publishing Co., Amsterdam.

62. Brewer, R., and J. A. Ellis. 1958. An analysis of migrating birds killed at a television tower in east-central Illinois, September 1955-May 1957. Auk 75:400-414.

63. Bridges. J. E. 1975. Biological effects of high voltage electric fields: bibliography and survey of ongoing work, 1975. Final Report, IIT Research Institute, Chicago, Ill. 313 pp.

64. _______. 1977. Environmental considerations concerning the biological effects of 60 hertz electric field environments. Paper presented at the 1977 IEEE Winter Power Meeting.

65. Bull, E. 1975. Habitat utilization of the Pileated Woodpecker. M. S. Thesis, Oregon State University, Corvallis.

66. Burgess, R. L. 1977. Power plants, transmission lines, and North American environment. J. Environ. Manage. In press.

67. Busby, K., D. Driscoll, and W. E. Washbon. 1974. A field survey of farmer experience with 765-kV transmission lines. Report issued by the Agricultural Resources Commission, State Campus. Albany, New York.

68. Byrd, M. S. 1956. Relation of ecological succession to farm game in Cumberland County in the Virginia Piedmont. J. Wildl. Manage. 20:188-195.

69. Carvell, K. L. 1976. Effects of herbicidal management of electric transmission line rights-of-way on plant communities. Pages 177-181 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

70. Cassiano, O., S. Troncone, and Q. Carta. 1966. Electrical fields: some neurovegetative responses in man. Minerva Anestesiolgica. 32:30-32. Translated from Italian for BPA by Leo Kanner Associates. May, 1976.

71. Cavanagh, J. B., D. P. Olson, and S. N. Macrigeanis. 1976. Wildlife use and management of powerline rights-of-way in New Hampshire. Pages 275-286 in R Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

72. Central Illinois Light Company v. Porter (Testimony). 1968. North Eastern Reporter, 2nd Series 239:298-301.

73. Chadwick, D. H. 1973. Mountain goat ecology-logging relationships in the Bunker Creek drainage of western Montana. M.S. Thesis, University of Montana, Missoula. 262 pp.

74. Chappell, W. E., J. S. Coartney, and J. B. Will. 1976. The use of plant growth regulators in rights-of-way maintenance. Pages 183-188 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

75. Coate, W. B., et al. 1970. Project Sanguine biological effects test program pilot studies final report. Prepared for Naval Electronics Systems Command Headquarters, Washington, D.C.

76. Cochran, W. W., and R. R. Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bull. 70:378-380.

77. Cody, J. B. 1975. Vegetation management on power line rights-of-way. A state of the knowledge report. S.U.N.Y. College of Environmental Science and Forestry, Syracuse. AFRI Research Report 28. 17 pp.

78. ________, and J. R. Quimby. 1975. Vegetation management on utility rights-of-way: An annotated bibliography. S.U.N.Y. College of Environmental Science and Forestry, Syracuse. AFRI Research Report 27. 56 pp.

79. Comber, M. B., and L. E. Zaffanella. 1975. Audible noise. Pages 192-238 in General Electric Co., transmission line reference book - 345 kV and above. Electric Power Research Institute, Palo Alto, Calif. 393 pp.

80. Conner, R. N., and C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. J. For. 13:485-488.

81. Conner, R. N., and H. S. Crawford. 1974. Woodpecker foraging in Appalachian clearcuts. J. For. 72:564-566.

82. Cornwell, G. W. 1968. Needless duck deaths. Conservation Catalyst 2:15-18.

83. _______, and H. A. Hochbaum. 1971. Collisions with wires - a source of anatid mortality. Wilson Bull. 83:305-306.

84. Crawford, R. L. 1971. Predation on birds killed at a TV tower. Oriole 36:33-35.

85. Crawford, J. E., and L. A. Dunkeson. 1973. Powerline standards to reduce raptor losses on the national resource lands. Draft report, U.S. Bureau of Land Management and U.S. Bureau of Sport Fisheries and Wildlife.

86. Cromer, J., and H. C. Smith. 1968. Sufficient deer browse produced by a wide range of cutting practices. Trans. N.E. Sect. Wildl. Soc., 25th N.E. Fish and Wildl. Conf. pp. 25-33.

87. Daubenmire, R. 1969. Structure and ecology of coniferous forests of the northern Rocky Mountains. Pages 24-50 in R. D. Taber (ed.), Coniferous forests of the northern Rocky Mountains. Proceedings of the 1968 symposium.

88. Davis, W., Jr. 1973. Ozone formed by high-voltage transmission line coronas. Oak Ridge National Lab. Monitoring Agency Rept. No. 18, Oak Ridge, Tenn. 7 pp.

89. Day, T. A. 1973. Summer and fall elk distribution, movements and range use in the Little Belt Mountains. M.S. Thesis, Montana State University Bozeman. 70 pp.

90. Della-Bianca, L. Johnson, and F. M. Johnson. 1965. Effect of an intensive clearing on deer-browse production in the southern Appalachians. J. Wildl. Manage. 29:729-733.

91. deLorge, J. 1972. Operant behavior of rhesus monkeys in the presence of extremely low frequency - low intensity magnetic and electric fields: Experiment 1. Naval Aerospace Medical Research Laboratory. Pensacola, Florida.

92. Deno, D. W. 1974. Calculating electrostatic effects of overhead transmission lines. IEEE transactions on Power Apparatus and Systems, Vol. PAS-93. p. 1458.

93. _________, and L. E. Zaffanella. 1975. Electrostatic effects of overhead transmission lines and stations. Pages 248-280 in General Electric Co., Transmission line reference book - 345 kV and above. Electric Power Research Institute, Palo Alto, Calif. 393 pp.

94. Diamond, J. M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biol. Conserv. 7:129-146.

95. _________. 1976. Island biogeography and conservation: strategy and limitations. Science 193:1027-1029.

96. Dickinson, L. E. 1957. Utilities and birds. Audubon 59:54-55, 86-87.

97. Dilger, W. C. 1954. Electrocution of parakeets at Agra, India. Condor 50:102-103.

98. Doucet, G. J., J. R. Sarrazin, and J. R. Bider. 1974. Use of highway overpass embankments by the woodchuck, Marmota monax. Can. Field-Nat. 88:187-190.

99. Downey, T. 1976. Emphasizing the benefits of the environmental rehabilitation of natural gas pipeline rights-of-way. Pages 232-240 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

100. Edgerton, P. J. 1972. Big game use and habitat changes in a recently logged mixed conifer forest in northeastern Oregon. Western Proceedings, 52nd Annual Conf. W. Assoc. State Game and Fish Comm. Portland, Ore. pp. 239-246.

101. Edwards, D. K. 1961. Influence of electrical field on pupation and oviposition in Nepytia phantasmaria Stkr. (Lepidoptera: Geometridae). Nature 191:976, 993.

102. Egler, F. E. 1953a. Our disregarded rights-of-way -- ten million unused wildlife acres. Trans. N. Amer, Wildl. Conf. 18:147-158.

103. ________. 1953b. Vegetation management for rights-of-way and roadsides. Smithsonian Inst. Ann. Rep. 1953:299-322.

104. ________. 1957. Rights-of-way and wildlife habitat: progress report. Trans. N. Amer. Wildl. Conf. 22:133-144.

105. ________. 1958. Science, industry, and the abuse of rights-of-way. Science 127:573-580.

106. ________. 1973. Bibliography of papers by Frank E. Egler concerning right-of-way vegetation management, herbicides and society. Conn. Conserv. Assoc., Bridgerwater, Conn. 8 pp.

107. Electric Power Research Institute. 1975. Study of environmental impact of underground electric transmission systems. EPRI 7826. 191 pp.

108. Ellis, D. H., D. G. Smith, and J. R. Murphy. 1969. Studies on raptor mortality in western Utah. Gt. Basin Nat. 29:165-167.

109. Ellison, R. J. 1977. Chamberlain Creek Study. Pages 93-122 in Montana Cooperative Elk-logging Study, Annual Progress Report.

110. Environmental Protection Agency. 1971. Effects of noise on wildlife and other animals. NTID 300.5 Washington, D.C.: Government Printing Office.

111. Federal Power Commission. 1971. The 1970 national power survey. Part I. U.S. Govt. Printing Office. Washington, D.C.

112. Fern, W. J., and R. I. Brabets. 1974. Field investigation of ozone adjacent to high voltage transmission lines. 1EEE Transactions on Power Apparatus and Systems. Vol. PAS-93, p. 1269.

113. Fisher, H. I. 1966. Midway's deadly antennas. Audubon 68:220-223.

114. Fitzner, R. E. 1975. Raptor mortality on fences and utility lines. Raptor Res. 9:55-56.

115. Fog, J. 1970. Effect of high voltage electrical lines on flying height of Anatidae. Flora Fauna, Silkeborg 76:141-144. (Engl. summ.)

116. Forman, R. T. T., A. E. Galli, and C. F. Leck. 1976. Forest size and avian diversity in New Jersey woodlots with some land use implications. Oecologia 26:1-8.

117. Foster, C. H. W. 1956. Wildlife use of utility right-of-way in Michigan. M. S. Thesis, University of Michigan, Ann Arbor.

118. Fowler, D. K., L. C. Marcum, R. R. Pugh, and D. C. Franscisco. 1976. Cooperative wildlife habitat development along transmission line corridors. Pages 295-302 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

119. Frydman, M., A. Levy, and S. E. Miller. 1972. Oxidant measurements in the vicinity of energized 756 kV lines. IEEE Transaction Paper T 72 551-0.

120. Galli, A. E., C. F. Leck, and R. T. T. Forman. 1976. Avian distribution patterns in forest islands of different sizes in central New Jersey. Auk 93:356-364.

121. Gardner, W. R., R. F. Harris, and C. B. Tanner. 1975. Response of plants and soil microorganisms to extremely low frequency electric fields. Final Report, submitted to Office of Naval Research. Department of Soil Science, University of Wisconsin, Madison. 84 pp.

122. Gashweiler, J. S. 1970. Plant and mammal changes on a clearcut in west-central Oregon. Ecology 51:1018-1026.

123. Gavalas-Medici, R. and Day-Magdaleno, S. R. 1976. Extremely low frequency, weak electric fields affect schedule controlled behavior of monkeys. Nature 261:256-259.

124. General Electric Company. 1975. Transmission line reference book, 345 kV and above. Electric Power Research Institute, Palo Alto, California.

125. Gollop, M. A. 1965. Bird migration collision casualties at Saskatoon. Blue Jay 23:15-17.

126. Good, E.E., and C. A. Damback. 1943. Effect of land use practices on breeding bird populations in Ohio. J. Wildl. Manage. 7:291-297.

127. Goodland,R. (ed.). 1973. Power lines and the environment. Cary Arboretum of New York Botanical Gardens, Millbrooke, N.Y. 172 pp.

128. Goodwin, J. G., Jr. 1975. Big game movement near a 500 kV transmission line in northern Idaho. Prepared for Bonneville Power Administration, Engineering and Construction Division, Portland, Oregon. 56 pp.

129. Goodwin, R. H., and W. A. Niering. 1959. The management of the roadside by selective herbicide techniques. Proc. 13th Ann. Meeting N.E. Weed Control Conf. 13:530-532.

130. Graf-Webster, E., S. Lubore, and J. Pfeffer. 1974. Resource and land investigations (RALI) program: methodologies for environmental analysis. Vol. II. Utility corridor selection. Mtr-6740, Vol. II, 84 pp. Mitre Corp., McLean, Va.

131. Griffith, D. B. 1977. Selected biological parameters associated with a ± 400 kV D-C transmission line in Oregon. Prepared for Bonneville Power Administration, Portland, Oregon. 94 pp.

132. Grue, C. E. 1977. The impact of powerline construction on birds in Arizona. M. S. Thesis, Northern Arizona University, Flagstaff. 265 pp.

133. Gunter, G. 1956. On the reluctance of gulls to fly under objects. Auk 73:131-132.

134. Gysel, L. W. 1957. Effects of silvicultural practices on wildlife food and cover in oak and aspen types in northern Michigan. J. For. 55:803-809.

135. ________. 1962. Vegetation changes and animal use of a power line right-of-way after the application of a herbicide. Down to Earth 18:7-10.

136. ________. 1962. Vegetation and animal use of a power line right-of-way in southern Michigan. Mich. Quart. Bull. 44:697-713.

137. ________, and W. Lemmien. 1955. The growth and wildlife use of planted shrubs and trees at the W. K. Kellogg multiple use forest. Mich. Agri. Expt. Quart. Bull. 38:139-145.

138. Hagar, D. C. 1960. The interrelationships of logging, birds, and timber regeneration in the Douglas fir region of northwestern California. Ecology 41:116-125.

139. Hamer, J. 1968. Effects of low level, low frequency electric fields on human reaction time. Community Behavior Biology, 2:A.

140. Hancock, N. J. 1963. Impact of interstate highways upon the wildlife resource. Proc. Ann. Conf. West. Assoc. State Game and Fish Comm. 43:183-187.

141. Hankla, D. 1959. Utility rights-of-way -- wildlife lands of promise. Wildl. in N. Carolina 23:18-19.

142. Hannum, G., W. Anderson, and M. Nelson. 1974. Power lines and birds of prey. Paper presented at the Northwest Electric Light and Power Association Engineering and Operating Conference, Yakima, WA.

143. Harrison, J. 1963. Heavy mortality of mute swans from electrocution. Wildfowl Trust, 1961-62. 14:164-165.

144. Haverlack, E. G., E. D. Michael, and C. R. Ferris. 1974. Song bird occurrence around highway interchanges. Proc. N.E. Wildl. Conf. 31:33-43.

145. Healey, W. M. 1975. Forage preferences of tame deer in a northwest Pennsylvania clear cutting. J. Wildl. Manage. 35:717-723.

146. Heath, M. L. 1973. Small mammal populations in clearcuts of various ages in south central Montana. M. S. Thesis, Montana State University, Bozeman.

147. Hendrickson, J. R. 1949. A hummingbird casualty. Condor 51:103.

148. Herrington, L. P., and G. M. Heisler. 1973. Microclimate modification due to power transmission rights-of-way. In R. Goodland (ed.), Power lines and the environment. The Cary Arboretum of the New York Botanical Gardens. Millbrook, N.Y.

149. Hickey, M. B. 1960. Migrants at airport ceilometers. Passenger Pigeon 22:23-26.

150. Hildebrand, P. R. 1971. Biology of white-tailed deer on winter ranges in the Swan Valley, Montana. M. S. Thesis, University of Montana, Missoula.

151. Hill, C. E. 1963. Rights-of-way for wildlife. Wildl. in N. Carolina, Feb. 1963. pp. 8-10.

152. Hoaglin, Earl D. No date. Bird nest problem: a possible solution. Unpubl. report to Bonneville Power Administration.

153. Hodges, T. K., G. A. Mitchell, and G. Heydt. 1975. Effect of electric fields from 765 kV transmission lines on plant growth. A study conducted for the Indiana and Michigan Electric Company, a subsidiary of American Electric Power Service Corporation. New York.

154. Hollenbaugh, W. C. 1974. Snowmobiles and off-road vehicles in Montana... a review of the literature. Mont. Dept. of Fish and Game, Helena. 39 pp.

155. Hooper, R. G., III. 1967. The influence of habitat disturbance on bird populations. M. S. Thesis, Virginia Poly. Inst., Blacksburg. 134 pp.

156. ________, and H. S. Crawford. 1969. Woodland habitat research for nongame birds. Trans. N. Am. Wildl. Nat. Resour. Conf. 34:201-207.

157. Hooper, R. G., III., H. S. Crawford, and R. F. Harlow. 1973. Bird density and diversity as related to vegetation in forest recreation areas. J. For. 71:766-669.

158. Hooven, E. F. 1969. The influence of forest succession on populations of small animals in western Oregon. Pages 30-34 in H. C. Black (ed.), Wildlife and reforestation in the Pacific Northwest. School of Forestry, Oregon State Univ., Corvallis. 92 pp.

159. ________, and H. C. Black. 1976. Effects of some clearcutting practices on small-mammal populations in western Oregon. Northwest Science 50:189-208.

160. Huff, D.E., and P. J. Savage. 1972. A correlation of deer movements with snowmobile activity in central Minnesota during winter, 1972. Midwest Wildl. Conf., Des Moines. 15 pp.

161. _______, D.C. Urich, and R.L. Watlor. 1972. Wildlife-snowmobile interaction project preliminary report covering period November 1971 - April 1972. U. of Minn. and Minn. Dept. of Nat. Res.

162. Humell, J. C., A. R. Laskey, and J. T. Tanner. 1954. Bird mortality at an airport ceilometer. Wilson Bull. 66:207-215.

163. Hungerford, J. E. 1969. Influence of forest management on wildlife. Pages 39-41 in H. C. Black (ed.), Wildlife and reforestation in the Pacific Northwest. School of Forestry, Oregon State Univ., Corvallis. 92 pp.

164. Hunt, R. A. 1972. Some field and court case experiences with waterfowl and electrical powerlines. Midwestern Wildlife Conference, Des Moines, Iowa, Dec. 10-13, 1972. Unpubl.

165. Hylten-Cavallins, N. 1975. Certain ecological effects of high voltage power lines. Report No. 1 REQ-1160, Institut de recherche de l' Hydro-Quebec, Varennes, Quebec, Canada.

166. Ibberson, J. E. 1956. Everyone benefits from vegetation management on rights-of-way. Northeast Logger 4:14-15, 36-39.

167. Jackman, S. M. 1974. Cavity nesting birds - can we ever leave enough snags? Technical Paper 3873, Oregon Ag. Expt. Sta.

168. Jackson, J. A. 1976. Right-of-way management for an endangered species: the red-cockaded woodpecker. Pages 247-252 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

169. Jacobson, J. S., and A. C. Hill (eds.). 1970. Recognition of air pollution injury to vegetation: a pictorial atlas. Air Pollution Control Association, Pittsburgh, Pennsylvania.

170. Jaffe, L. S. 1967. The biological effects of ozone on man and animals. Am. Industrial Hygiene Assoc. J. 28:267-277.

171. Jarvinen, J. A., and W. D. Schmid. 1971. Snowmobile use and winter mortality of small mammals. pp. 130-141 In: M. Chubb (ed.), Snowmobile and Off-the-Road Vehicle Res. Symp. Proc., Dept. Park and Recreation Resour., Michigan State Univ., East Lansing.

172. Johansson, R., A. G. Lundquist, S. Lindquist, and V. Scuka. 1973. Is there a connection between the electricity in the atmosphere and the function of man? Part 3. 50-Hz field variations. Translation of FOA report dated September, 1973.

173. Johns, H. R. 1976. Regulatory aspects of management of rights-of-way. Pages 189-204 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

174. Johnson, D. R., and R. M. Hansen. 1969. Effects of range treatment with 2,4-D on rodent populations. J. Wildl. Manage. 33:125-132.

175. Johnson. R. E. 1970. The effects of highways on wildlife. Prescott College Ecological Survey, Prescott, Arizona. 40 pp.

176. Johnston, D. W. 1954. Mass bird mortality in Georgia. The Oriole 30:17.

177. ________. 1970. High densities of birds breeding in a modified deciduous forest. Wilson Bull. 82:79-82.

178. ________, and T. P. Haines. 1957. Analysis of bird mortality in October 1954. Auk 74:447-458.

179. Joselyn, G. B. 1969. Wildlife -- an essential consideration determining future highway roadside maintenance policy. Highway Res. Record. 280:1-14.

180. Joslin, G. B. 1975. Behavior and environmental selection by elk (*Cervus canadensis nelsoni*) during summer and fall in the First and Second Yellow Mule Drainages, Madison County, Montana. M. S. Thesis, Montana State University, Bozeman.

181. Kale, H. W.,II, M. H. Hundley, and J. A. Tucker. 1969. Tower-killed specimens and observation of migrant birds from Grand Bahama Island. Wilson Bull. 81:258-263.

182. Kaufman, G. E., and S. M. Michaelson. 1974. Critical review of the biological effects of electric and magnetic fields. Pages 49-61 *in* J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (eds.), Biological and Clinical Effects of Low-frequency Magnetic and Electric Fields. Charles C. Thomas, Springfield, Ill. 345 pp.

183. Keith, J. O., R. M. Hansen, and A. L. Ward. 1959. Effect of 2,4-D abundance and foods of pocket gophers. J. Wildl. Manage. 23:137-145.

184. Kelker, G. H. 1964. Appraisal of ideas advanced by Aldo Leopold thirty years ago. J. Wildl. Manage. 28:180-185.

185. Kemper, C. A. 1958. Bird destruction at a T.V. tower. Audubon 60:270-271, 290-293.

186. ________. 1964. A tower for T.V.: 30,000 dead birds. Audubon 66:86-90.

187. ________, D. G. Raveling, and D. W. Warner. 1966. A comparison of the species composition of two T.V. tower killed samples from the same night of migration. Wilson Bull. 78:26.

188. Kennedy, James J. 1973. Some effects of urbanization on big and small game management. Trans. N. Am. Wildl. Conf. 38:248-255.

189. Kenyon, K. W. 1940. Black vultures perch on telephone wires. Condor 43:222-223.

190. Kirsch, J. B. 1962. Range use, relationship to logging, and food habits of the elk in the Little Belt Mountains. M. S. Thesis, Montana State University, Bozeman. 44 pp.

191. Kitchings, J. T., H. H. Shugart, and F. D. Story. 1973. Environmental impacts associated with electric transmission lines. Draft report by Oak Ridge National Laboratory for U.S. AEC under contract No. W-7405-eng. 26. 111 pp.

192. Klein, D. R. 1971. Reaction of reindeer to obstructions and disturbances. Science 173:393-398.

193. Knickerbocker, G. G., W. B. Kouwenhoven, and H. C. Barnes. 1967. Exposure of mice to a strong AC field - an experimental study. 1EEE transactions on power apparatus and systems, PAS-86 (April 1967), pp. 498-505.

194. Kornberg, H. A. 1976. EPRI's research program on biological effects of electric fields. Pages 135-142 _in_ R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

195. Korobhova. V. P., Y. A. Morozov, M. D. Stolarov, and Y. A. Yakub. 1972. Influence of the electric field in 500 and 750 kilovolt switchyards on maintenance staff and means for its protection. Presented at International Conference on Large High Tension Electric Systems (CIGRE), Paris, August-Sept., 1972; report available from USDI Engineering and Research Center, Washington, D.C.

196. Kouwenhoven, W. B., O. R. Langworthy, and M. L. Singewald. 1967. Medical evaluation of man working in AC electric fields. 1EEE Transactions, PAC-86 (April 1967), 510.

197. Kraeger, R. H. 1976. Right-of-way restoration: mitigating the impact. Pages 242-244 _in_ R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

198. Krapu, G. L. 1974. Avian mortality from collisions with overhead wires in North Dakota. Prairie Nat. 6:1-6.

199. Krefting, L. W., and H. C. Hansen. 1963. Use of phytocides to improve deer habitat. Southern Weed Conf. Proc. 16:209-216.

200. Kretzschmar, H. 1969. Grosstrappen fliegen gegen Hochspannungs-leitung. Falke 16:94-95.

201. Krueger, W. F.,A. J. Giarola, J. W. Bradley, and A. Shrehenhamer. 1974. The effect of electromagnetic fields on fecundity in the chicken. Submitted to New York Acad. of Sciences, N.Y.

202. Krull, J. N. 1970. Small mammal populations in cut and uncut northern hardwood forests. N.Y. Fish and Game. J. 17:128-130.

203. Lahrman, F. W. 1965. Regina and Lumsden T.V. tower bird mortalities, 1964. Blue Jay 23:18-19.

204. Lancia, R. A., and C. A. McConnell. 1976. Wildlife management on utility company rights-of-way: results of a national survey. Pages 307-314 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

205. Landes, R. K. 1967. Selective maintenance of utility rights-of-way on national forest lands in Indiana and Ohio. 7th Ann. Conf. of the Ohio Wildl. Manage. Assoc. 5 pp.

206. Larkin, R. P., and P. J. Sutherland. 1977. Migrating birds respond to project Seafarer's electromagnetic field. Science 195:777-778.

207. Laskey, A. R. 1960. Bird migration casualties and weather conditions, Autumns 1958-1959-1960. Migrant 31:6-65.

208. _______. 1969a. T.V. tower casualties at Nashville in Autumn 1968. Migrant 40:25-27.

209. _______. 1969b. Autumn 1969 T.V. tower casualties at Nashville. Migrant 40:79-80.

210. Latham, R. M. 1956. Rights-of-way for wildlife. Pennsylvania Game News 27:19-23.

211. Lawrence, W. H. 1967. Effects of vegetation management on wildlife. Pages 88-93 in Herbicides and Vegetation Management. Symp. Proc., Oregon State University, Corvallis.

212. Lay, D. W. 1938. How valuable are woodland clearings to birdlife? Wilson Bull. 50:254-256.

213. Lee. J. M., Jr. 1974. Preliminary investigations of elk migration in relation to electric power transmission lines. Unpubl. report, Bonneville Power Administration.

214. __________. 1976. A study of the effects of BPA transmission structures on raptors and the experimental installation of raptor nesting platforms. Project description and environmental analysis. Bonneville Power Administration, Portland.

215. __________. 1977. Bird collisions with transmission lines -- a preliminary study of a 230 kV transmission line. MS prepared for submittal to Wilson Bull.

216. _______, and D. B. Griffith. 1977. Transmission line audible noise and wildlife. (Abstract). Intl. Congr. Acoustics 9:897.

217. Leedy, D. L. 1975. Highway-wildlife relationships. Vol. 1. A state-of-the art report. Report No. FHWA-RD-76-4, Federal Highway Administration, Washington, D.C. 183 pp.

218. ________, T. M. Franklin, and E. C. Hekimian. 1975. Highway-wildlife relationships. Vol. 2. An annotated bibliography. Report No. FHWA-RD-76-5, Federal Highway Administration, Washington, D.C. 417 pp.

219. Lemke, T. O. 1975. Movement and seasonal ranges of the Burdette Creek elk herd, and an investigation of sport hunting. M. S. Thesis, University of Montana, Missoula.

220. Leonard, J., and S. A. Cain. 1961. The role of herbicides in wildlife management. Pages 1422-1426 in Recent Advances in Botany. Univ. of Toronto Press.

221. Leopold, A. 1933. Game Management. Charles Scribner's Sons, New York. 481 pp.

222. ________. 1969. Adaptability of animals to habitat change. Pages 51-63 in G. W. Cox (ed.), Readings in Conservation Ecology. Appleton-Century-Crofts, N.Y.

223. Leopold, L. B., F. E. Clarke, B. B. Hanshaw, and J. R. Bolsey. 1971. A procedure for evaluating environmental impact. Geological Survey Circular 645, Washington, D.C. 13 pp.

224. Linduska, J. P. 1950. Ecology and land-use relationships of small mammals on a Michigan farm. Mich. Dept. of Conservation, Game Div. 144 pp.

225. Llaurado, J. G., A. Sances, Jr., and J. H. Battocletti (eds). 1974. Biologic and clinical effects of low-frequency magnetic and electric fields. Charles C. Thomas, Springfield, Illinois. 345 pp.

226. Longcore, J. R. 1971. Powerline right-of-way. Amer. Birds. 25:997-998.

227. Lonner, T. N. 1974. Effects of a road closure on elk distribution in the Ruby River drainage. Mont. Dept. of Fish and Game, Project No. W-120-R-5, Job No. BG-3.07.

228. Lott, J. R., and H. B. McCain. 1973. Some effects of continuous and pulsating electric fields on brain wave activity in rats. Int. J. Biometeor. 17(3):221-225.

229. Lyon, L. J. 1973. Effects on elk distribution in Burdette Creek. Proc. Western States Elk Workshop. Bozeman, Mt. pp. 119-120.

230. ________. 1974. Annual pellet count surveys to describe elk distribution patterns within the Burdette Creek-Deer Creek Area. Cooperative Elk-Logging Study Progress Report. August 1974. pp. 10-28.

231. ________, and R. Janson. 1974. Elk-logging relationships in Burdette Creek. Mont. Dept. of Fish and Game. Project No. W-120-R-5, Job No. BG-3.08.

232. MacArthur,R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton.

233. McCaffery, K. R. 1973. Road-kills show trends in Wisconsin deer populations. J. Wildl. Manage. 37:212-216.

234. McClelland, B. R. 1977. A study of forest snags and hole-nesting birds. Ph.D. Thesis, University of Montana, Missoula.

235. McClintock, L., R. F. Whitcomb, and B. L. Whitcomb. 1977. Island biogeography and "habitat islands" of eastern forest. II. Evidence for the value of corridors and minimization of isolation in preservation of biotic diversity. Amer. Birds 31:6-16.

236. McGinnes, B. S. 1969. How size and distribution of cutting units affect food and cover of deer. Pages 66-70 in White-tailed Deer in the Southern Forest Habitat (symposium). U.S. Dept. Agr. Forest Service, Southern Forest Expt. Sta. 130 pp.

237. McKenna, M. G., and G. E. Allard. 1976. Avian mortality from wire collisions. N. Dakota Outdoors 39(5):16-18.

238. McLay, C. L. 1974. The species diversity of New Zealand forest birds: some consequences of the modification of beech forests. New Zealand J. Zool. 1:179-196.

239. Madson, J. 1969. Ruffed grouse. Conservation Department, Olin Mathieson Chem. Corp., East Alton, Ill. 103 pp.

240. Manville, R. H. 1966. Roadside abundance of woodchucks. Amer. Midland Nat. 75:537-538.

241. Marcum, C. L. 1971. Vegetal development on montane fir clearcuts in western Montana. M. S. Thesis, University of Montana, Missoula. 122 pp.

242. ________. 1975. Summer-fall habitat selection and use by a western Montana elk herd. Ph.D. Thesis, University of Montana, Missoula.

243. Martinka, R. 1974. The new horizon. Montana Outdoors 5:16-21.

244. Maruvada, P. S., N. H. Cavallius, N. G. Trinh, and M. DeVizio. 1976. Electrostatic field effects from high voltage power lines and in substations. Paper 36-04 presented at the International Conference on Large High Voltage Electric Systems.

245. Mayer, T. D. 1974. Evaluation of chemically-sprayed electric transmission line rights-of-way for actual and potential wildlife use. M. S. Thesis, West Virginia University.

246. ________. 1976. An evaluation of chemically-sprayed electric transmission line rights-of-way for actual and potential wildlife use. Pages 287-294 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

247. Mayfield, H. 1967. Shed few tears. Audubon 69:61-65.

248. Mayyasi, A. M., and R. A. Terry. 1969. Effects of direct electric fields, noise, sex and age on maze learning in rats. Int. J. Biometeor. 13(2):101-111.

249. Michael, E. D., C. R. Ferris, and E. G. Haverlack. 1976. Effects of highway rights-of-way on bird populations. Pages 253-262 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

250. Miller, D., E. L. Boeker, R. S. Thorsell, and R. R. Olendorff. 1975. Suggested practices for raptor protection on powerlines. Raptor Research Foundation, Inc., Provo, Utah.

251. Montana Department of Natural Resources and Conservation. Transmission line guidebook. In preparation.

252. Mose, J. R., and G. Fischer. 1970. Effect of electrostatic fields: results of further animal experiments. Arch. Hyg. Bakteriol. 154:378-86. Translated for BPA by E. Gerzenstein, 1973.

253. Murr, L. E. 1966a. The biophysics of plant growth in a reversed electrostatic field: a comparison with conventional electrostatic and electrokinetic field growth responses. Int. J. Biometeor. 10(2):135-146.

254. Murr, L. E. 1966b. Physiological stimulation of plants using delayed and regulated electric field environments. Int. J. Biometeor. 10(2):147-153.

255. Myers, Lewis. 1977. Sage grouse collisions on ten mile powerline (230 kV). Unpublished memorandum, USDI Bureau of Land Management, Dillon, Montana.

256. Nelson, M. 1975. Power lines and birds of prey. Aware 52:9-12.

257. ________, and P. Nelson. 1976. Power lines and birds of prey. Idaho Wildl. Review, March-April.

258. Nero, R. W. 1961. Regina T.V. tower bird mortalities - 1961. Blue Jay 19:160-164.

259. Newmann, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. Can. Field-Nat. 86:207-212.

260. Newton, M., and L. A. Norris. 1968. Herbicide residues in blacktail deer from forests treated with 2,4,5-T and atrazine. In Proc. Western Society of Weed Science 22. Boise, Idaho.

261. Niering, W. A. 1958. Principles of sound right-of-way vegetation management. Econ. Bot. 12:140-144.

262. _______. 1967. Connecticut's rights-of-way: their conservation values. Conn. Woodlands 32:6-9.

263. _______, and R. H. Goodwin. 1974. Creation of relatively stable shrublands with herbicides: arresting "succession" on rights-of-way and pastureland. Ecology 55:784-795.

264. Noland, V., Jr., and R. E. Mumford. 1965. An analysis of prairie warblers killed in Florida during nocturnal migration. Condor 67:322-338.

265. Northern Prairie Wildlife Research Center. 1974. Investigations of bird migration and bird mortality at the Omega Navigation Station, Lamoure, North Dakota, 1969, 1971, 1972, 1973. U.S. Bureau of Sport Fisheries and Wildlife, Jamestown, N.D.

266. Nyquist, M. O. 1973. Deer and elk utilization of successional forest stages in northern Idaho. Ph.D. Dissertation, Washington State University, Pullman. 86 pp.

267. Oetting, R. B. 1971. Right-of-way resources of the prairie provinces. Blue Jay 29:179-183.

268. Ogden, J. 1960. Observations at a T.V. tower during a bird fall. Migrant 31:65-67.

269. Ogilvie, M. A. 1967. Population changes and mortality of the mute swan in Britain. Wildfowl Trust, 1965-66. 18:64-73.

270. Olendorff, R. R. 1972. Eagles, sheep and powerlines. Colorado Outdoors 1:3-11.

271. Oxley, I. J., M. B. Fenton, and G. R. Carmody. 1974. The effects of roads on populations of small mammals. J. Applied Ecol. 11:51-59.

272. Page, R. D., and J. F. Cassel. 1971. Waterfowl nesting on a railroad right-of-way in North Dakota. J. Wildl. Manage. 35:544-549.

273. Patton, D. R. No date. Deer and elk use of a ponderosa pine forest in Arizona before and after timber harvest. USDA Forest Service Research Note RM-139. 7 pp.

274. _______. 1974. Patch cutting increases deer and elk use of a pine forest in Arizona. J. For. 72:764-766.

275. _______. 1975. A diversity index for quantifying habitat "edge." Wildl. Soc. Bull. 3:171-173.

276. Pengelly, W. L. 1963. Timberlands and deer in the northern Rockies. J. For. 61:734-740.

277. _______. 1972. Clearcutting: detrimental aspects for wildlife resources. J. Soil and Water Conserv. 27:255-258.

278. ________. 1973a. Clearcutting and wildlife. Montana Outdoors 4:26-30.

279. ________. 1973b. Clearcutting: detrimental aspects for wildlife resources. Proc. Mont. Acad. Sci. 33:1-7.

280. Perkins, C. J. 1973. Effects of clearcutting and site preparation on the vegetation and wildlife in the flatwoods of Kemper County, Mississippi. Ph.D. Thesis, Mississippi State University, Starkville. 236 pp.

281. Perrins, C. M., and C. M. Reynolds. 1967. A preliminary study of the mute swan, *Cygnus olor*. Ann. Rep. Waterfowl Trust 18:74-84.

282. Perry, D. E. 1972. An analysis of transmission line noise levels based upon field and three-phase test line measurements. IEEE transactions on Power Apparatus and Systems, Vol. PAS-91. p. 857.

283. Phillips, R. D., R. L. Richardson, W. T. Kahne, D. L. Hjeresen, J. L. Beamer, and M. F. Gillis. 1976. Effects of electric fields on large animals: a feasibility study. Final Report to Electric Power Research Institute on Research Project RP 581-1. Battelle Pacific Northwest Laboratories, Richland, Washington. 73 pp.

284. Pierce, M. E. 1969. Tall television tower and bird migration. South Dakota Bird Notes 21:4-5.

285. Potash, L. M. 1972. A signal detection problem and possible solution in Japanese Quail (*Coturnix coturnix Japanica*). Anim. Behav. 20:192-195.

286. Pound, C. E., and F. E. Egler. 1952. Report on stable 15-year old right-of-way vegetation in New York State. So. Weed Conf. Proc. 145-147.

287. Quortup, E. R., and J. E. Schillinger. 1941. 3,000 wild bird autopsies on western lake areas. J. Am. Vet. Med. Assoc. 99:382-387.

288. Ream, R. 1973. Effects of logging on elk in the Sapphire Mountains. Proc. W. States Elk Workshop, Bozeman, Montana. pp. 125-129.

289. ________, R.Beall, and L. Marcum. 1972. Sapphire elk ecology study--elk, logging, and people. 2nd Ann. Rpt. School of Forestry, University of Montana, Missoula. 54 pp.

290. Regelin, W. L., A. C. Wallace, J. Magy, and D. R. Dietz. 1974. Effect of logging on forage values for deer in Colorado. J. For. 72:282-287.

291. Rehder, J. B. 1972. The applicability of remote sensing to detection, identification, and monitoring of power transmission rights-of-way within selected areas of the TVA region. Final Report. Sponsored by NASA and TVA. Monitoring Agency Rept. 18. 14 pp.

292. Research Committee. 1977. Montana Cooperative Elk - Logging Study, Progress report for the Period January 1 - December 31, 1976. Montana Department of Fish and Game, Helena. 115 pp.

293. Reilley, R. E., and H. E. Green. 1974. Deer mortality on a Michigan interstate highway. J. Wildl. Manage. 38:16-19.

294. Resler, R. 1972. Clearcutting: beneficial aspects for wildlife resources. J. Soil and Water Conserv. 27:250-254.

295. Reynolds, H. G. 1966. Use of openings in spruce-fir forests of Arizona by elk, deer, and cattle. Forest Service Research Note RM-66. Rocky Mountain Forest and Range Experiment Station, U.S. Dept. of Agriculture, Ft. Collins, CO. 4 pp.

296. Richardson, G. L. no date. Raptors and powerlines. USDA Forest Service, Manti-La Sal National Forest. Unpublished.

297. Richter, W. C. 1958. Wildlife food and cover by the mile. Pennsylvania Game News 29:43-44.

298. Riesen, W. H. et. al. 1974. A pilot study of the interaction of extremely low frequency electromagnetic fields with brain organelles. IIT Research Institute Project E6185, technical memo no. 3 (Washington, D.C.: U.S. Naval Electronics Systems Command.)

299. Roach, J. F., V. Chartier, and F. M. Dietrich. 1973. Experimental oxidant production rates for EHV transmission lines and theoretical estimates of ozone concentrations near operating lines. IEEE Transactions on Power Apparatus and Systems, Vol. PAS-93. p. 647.

300. Roseberry, J. T., and J. A. Gill. 1975. Power transmission lines: an overview of problems,values, and potentials for wildlife. Trans. N. E. Sect. Wildl. Soc. 31:7-14.

301. Rost, G., and J. A. Bailey. 1974. Responses of deer and elk to roads on the Roosevelt National Forest. Proc. 25th N.W. Sect. Wild. Soc. Conf., Edmonton, Alberta. 19 pp.

302. Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57:773-782.

303. Rural Electrification Administration. 1973. Powerline contacts by eagles and other large birds. REA Bulletin 61-10. 6 pp.

304. ________. 1976. Electrostatic and electromagnetic effects of overhead transmission lines. REA Bulletin 62-4. U.S. Department of Agriculture, Rural Electrification Administration. Washington, D.C. 58 pp.

305. Sargeant, A. B., and J. E. Forbes. 1973. Mortality among birds, mammals and certain snakes on 17 miles of Minnesota roads. Loon 45:4-7.

306. Sassin, W. 1975. Aspects of electrical high-energy transmission and its influence on the environment. Monitoring Agency Rept. No. 18. 53 pp.

307. Schall, H. R. 1972. Constraint maps - the newest look in right-of-way selection. Transmission and Distribution 24:26-31.

308. Scherer, H. N., Jr., B. J. Ware, and C. H. Shih. 1972. Gaseous effluents due to EHV transmission line corona. IEEE Transaction Paper T 72 550-2.

309. Schiefelbein, G. F. 1977. Alternative electrical transmission systems and their environmental impact. Prepared for U.S. Nuclear Regulatory Commission by Batelle Pacific Northwest Laboratories. 113 pp.

310. Schmid, W. D. Modification of the subnivean microclimate by snowmobiles. Unpubl., 7 pp.

311. Schmidt, D., J. Elliott, G. Moore, and T. Olson. 1975. Powerline effects on vegetation (with special reference to southwestern Montana.) Prepared for Energy Planning Division, Montana Department of Natural Resources and Conservation, Helena. 131 pp.

312. Schmidt, E. 1973. Oekologische Auswirkung von elektrischen Leitungen und Masten sowie deren Accessorien auf die Voegel (The ecological effects of electrical lines and their poles and accessories.) Beitr. Vogelkd. 19:342-362.

313. Schneider, K. H., et. al. 1974. Displacement currents in the human body caused by dielectric field under overhead lines. CIGRE: International Conference on Large High Voltage Electric Systems. Paris.

314. Schroeder, C. G. 1977. Geese hit power transmission line. North Dakota Outdoors.

315. Schreiber, R. K., and J. Graves. 1977. Powerline corridors as possible barriers to the movements of small mammals. Amer. Midland Nat. 97:504-508.

316. ________, W. C. Johnson, J. D. Story, C. Wenzel, and J. T. Kitchings. 1976. Effects of powerline rights-of-way on small nongame mammal community structure. Pages 263-274 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

317. Schwan, H. P. No date. Biological hazards from exposure to ELF electrical fields and potentials. NTIS AD-743480 National Techn. Inf. Serv., USDC, Springfield, VA.

318. Scott, R. E., L. J. Roberts, and C. J. Cadbury. 1972. Bird deaths from powerlines at Dungeness. British Birds 65(7):273-286.

319. Sebo, S. A., J. T. Heibel, M. Frydman, and C. H. Shih. 1976. Examination of ozone emanations from EHV transmission line corona discharges. IEEE PAS 95, pp. 693-703.

320. Shelton, L. R., III. 1976. Liability and resource conservation aspects of rights-of-way use. Pages 315-320 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

321. Shugart, H. H., R. D. Dueser, and S. H. Anderson. 1974. Influence of habitat alterations on bird and small mammal populations. Pages 92-96 in J. P. Slusher and T. M. Hinckly (eds.), Timber-wildlife Management Symposium Proc. University of Missouri, Columbia. 131 pp.

322. Siegfried, W. R. 1972. Ruddy ducks colliding with wires. Wilson Bull. 84:486-487.

323. Simberloff, D. S., and L. G. Abele. 1976. Island biogeography theory and conservation practice. Science 191:285-286.

324. Sims, H. P., and C. H. Buchner. 1973. The effect of clearcutting and burning of Pinus banksiana forests on the populations of small mammals in southeastern Manitoba. Amer. Midland Nat. 90:228-231.

325. Smith, E. R. 1959. Preliminary study of vegetation on North Carolina piedmont and mountain power transmission right-of-way. M. S. Thesis, N.C. State College.

326. Southern, W. E. 1975. Orientation of gull chicks exposed to project Sanguine's electromagnetic field. Science 189:143-145.

327. Sprunt, A., IV., et. al. 1973. Comparative productivity of six bald eagle populations. Trans. N. Amer. Wildl. Conf. 38:96-105.

328. Stahlecher, D. W. 1975. Impacts of a 230 kV transmission line on Great Plains wildlife. M. S. Thesis, Colorado State University, Ft. Collins. 67 pp.

329. Stehn, T. 1973. Daily movements and activities of cow elk in the Sapphire Mountains of western Montana during summer and fall. M. S. Thesis, University of Montana, Missoula. 66 pp.

330. Stelfox, J. G. 1962. Effects on big game of harvesting coniferous forests in western Alberta. For. Chron., pp. 94-107.

331. Stoddard, H. L. 1962. Bird casualties at a Leon County, Florida T.V. tower, 1955-1961. Tall Timber Res. Stat. Bull. No. 1. 94 pp.

332. ________, and R. A. Norris. 1967. Bird casualties at a Leon County, Florida T.V. tower: an eleven-year study. Tall Timber Res. Sta. Bull. No. 8. 104 pp.

333. Stout, I. J. 1967. The nature and pattern of nonhunting mortality in fledged North American waterfowl. M. S. Thesis, Virginia Polytechnic Institute.

334. ________, and G. W. Cornwell. 1976. Nonhunting mortality of fledged North American waterfowl. J. Wildl. Manage. 40:681-693.

335. Sullivan, A. L., and M. L. Shaffer. 1975. Biogeography of the megazoo. Science 189:13-17.

336. Sundstrom, C., and E. Norberg. 1972. A brief summary of the influence of roads on elk populations. USDI Fish and Wildlife Service, Division of River Basin Studies, Boise, Idaho. 34 pp.

337. Taber, R. D., et. al. 1973. Wildlife response to rights-of-way management. Report for July 1972-June 1973. College of Forest Resources, Center for Ecosystem Studies, University of Washington, Seattle.

338. Takagi, T., and T. Muto. 1971. Influences upon human bodies and animals of electrostatic induction caused by 500 kV transmission lines. Tokyo Electric Power Co., Inc. Tokyo, Japan. 25 pp.

339. Taylor, W. K. 1973. Black-throated blue and Cape May warblers killed in Central Florida. Bird-banding 44:258-266.

340. ________, and B. H. Anderson. 1973. Nocturnal migrants killed at a central Florida T.V. tower, autumns 1969-1971. Wilson Bull. 85:42-51.

341. Telfer, E. S. 1972. Forage yield and browse utilization on logged areas in New Brunswick. Can. J. For. Res. 2:346-350.

342. Terres, J. K. 1956. Death in the night. Audubon 58:18-20.

343. Tevis, L., Jr. 1956. Responses of small mammal populations to logging of Douglas Fir. J. Mamm. 37:189-196.

344. Thomas, J. W., C. Maser, and J. Rodiek. 1977. Edges -- their interspersion, resulting diversity and its measurement. USDA Forest Service, La Grande, Oregon.

345. Thompson, L. S. 1977a. Wildlife and land use change: some considerations in assessing impact risk. Western Wildlands 3:18-24.

346. ________. 1977b. Identification of critical wildlife habitat using an "impact risk" mapping technique. Presented at the Symposium on Classification, Inventory, and Analysis of Fish and Wildlife Habitat, Phoenix, AZ.

347. Tillman, R. E. 1973. Wildlife management -- powerline rights-of-way. Pages 127-132 in R. Goodland (ed.), Power Lines and the Environment. The Cary Arboretum, Millbrook, N.Y. 170 pp.

348. ________. 1976. The Southern Tier Interconnection: a case study. Pages 222-230 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

349. ________. (ed.). 1976. Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

350. ________, and R. Goodland. 1973. Environmental protection and wildlife management plan, the southern tier interconnection. The Cary Arboretum, Millbrook, N.Y. 190 pp.

351. Tordoff, H. B., and R. M. Mengel. 1956. Studies of birds killed in nocturnal migration. Univ. of Kansas Publ. of the Mus. of Nat. Hist. 10:3.

352. Ulrich, E. S. 1976. Selective clearing and maintenance of rights-of-way. Pages 206-219 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

353. USDA Forest Service. 1966. Vegetation management for rights-of-way: selective maintenance for improved wildlife habitat and scenic values. Eastern Region. 39 pp.

354. Vosburgh, J. 1966. Death traps in the flyways. In birds in our lives. U. S. Fish and Wildlife Service, Washington, D.C.

355. Wagner, J. F. 1971. Creating wildlife habitat on utility rights-of-way. Ind. Veg. Manage. 3:15-17.

356. Walkinshaw, L. H. 1956. Sandhill cranes killed by flying into power line. Wilson Bull. 68:325-326.

357. Wallmo, O. C. 1969. Response of deer to alternate-strip clearcutting of lodgepole pine and spruce-fir timber in Colorado. USDA Forest Service Research Note RM-141. 4 pp.

358. ________, W. L. Regelin, and D. W. Reschert. 1972. Forage use by mule deer relative to logging in Colorado. J. Wildl. Manage. 36:1025-1033.

359. Wanek, W. J. 1971. Observations on snowmobile impact. The Minn. Volunteer 34:1-9.

360. Ward, A. L. 1973a. Elk behavior in relation to multiple uses on the Medicine Bow National Forest. West. Assoc. State Game Fish Comm. Proc. 53:125-141.

361. ________. 1973b. Effects of logging and use of roads on elk behavior and distribution. Proc. W. States Elk Workshop. Bozeman, Mt. pp. 130-131.

362. ________, J. J. Cupal, A. L. Lea, C. A. Oakley, and R. W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. Trans. N. Am. Wildl. Nat. Resour. Conf. 38:327-337.

363. Warner, R. 1970. Some aspects of browse production in relation to timber harvest methods and succession in western Montana. M. S. Thesis, University of Montana, Missoula. 74 pp.

364. Weir, R. D. 1975. Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Canadian Wildlife Service, Ontario Region. 85 pp.

365. Wellenstein, G., 1973. The influence of high-tension lines on honeybee colonies (Apis mellifical L.). Zeitschrift Fur Angewandte Entomologie, pp. 86-94. Translated from German for Battelle-Northwest by Addis Translations International.

366. Wenger, J. S., and F. Denbrock. 1974. Corridor: a new system for environmental impact analysis. IEEE Conf. Paper, IEEE Power Engineering Society Winter Meeting, N.Y.

367. Werschkul, D. F.,E. McMahon, and M. Leitschuh. 1976. Some effects of human activities on the great blue heron in Oregon. Wilson Bull. 88:660-662.

368. West, H. J., H. E. Brown, and A. L. Kinyon. 1971. Simulations of EHV transmission line flashovers initiated by bird excretion. IEEE paper 71 TP 145-PWR.

369. Wetmore, S., C.H. Nellis, and L. B. Keith. 1970. A study of winter coyote hunting in Alberta with emphasis on use of snowmobiles. Wildl. Techn. Bull. 2, Fish and Wildl. Div., Alberta. Dept. of Lands and Forests. 22 pp.

370. Wheaton, F. W. 1970. Influence of electrical energy on plants: a review. Agricultural Experiment Station, University of Maryland, College Park.

371. Whitcomb, B. L., R. F. Whitcomb, and D. Bystrak. 1977. Island biogeography and "habitat islands" of eastern forest. III. Long-term turnover and effects of selective logging on the avifauna of forest fragments. Amer. Birds 31:17-23.

372. Whitcomb, R. F. 1977. Island biogeography and "habitat islands" of eastern forest. I. Introduction. Amer. Birds 31:3-5.

373. Whitmore, F. C., and R. L. Durfee. 1973. Determination of coronal ozone production by high voltage power transmission lines. Versar, Inc., Springfield, VA.

374. Willard, D. E., J. T. Harris, and M. J. Jaeger. 1977. The impact of a proposed 500 kV transmission line on waterfowl and other birds. Prepared for the Public Utility Commissioner of Oregon by D. E. Willard and Associates. 89 pp.

375. Willard, D. E., and B. J. Willard. 1972. The interaction between some human obstacles and birds. Institute for Environmental Studies, University of Wisconsin, Madison.

376. Williams, G. C. 1950. Weather and spring migration. Auk 67:52-65.

377. Winternitz, B. L. 1976. Temporal change and habitat preference of some montane breeding birds. Condor 78:383-393.

378. Witherspoon, J. P. 1972. Evaluating the environmental impact of electrical power generation on terrestrial systems. In Symp. of the National Environmental Policy Act: at the Interface of Law and Environmental Science. 139 AAS Mtg., Washington, D.C.

379. Woodhouse, C. B. 1972. Power line wildlife. Wildl. in N. Carolina. October: 10-11.

380. _______, and A. S. Baynes. 1976. Right-of-way maintenance through seeding and wildlife planting -- an economical answer with multiple use benefits. Pages 303-306 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

381. Young, L. B. 1973a. Forests of the future. Sierra Club Bull. 58:11.

382. _______. 1973b. Power over People. Oxford Univ. Press, N.Y. 216 pp.

383. _______. 1976. Environmental problems in extra high voltage transmission. Pages 125-134 in R. Tillman (ed.), Proceedings of the First National Symposium on Environmental Concerns in Rights-of-way Management. Mississippi State University. 335 pp.

384. _______, and H. P. Young. 1974. Pollution by electrical transmission - the environmental impact of high voltage lines. Bull. of the Atomic Scientists, 30:34-38.

385. Zahn, H. M. 1974. Seasonal movements of the Burdette Creek elk herd. M. S. Thesis, University of Montana, Missoula. 71 pp.